

Lamprey River

Protected Instream Flow Study



Lamprey River

Protected Instream Flow Study

- **Introduction**
- **Acceptance of meeting minutes**
- **Presentation of draft Lamprey PISFs**
 - **Natural flow paradigm concept**
 - **Lamprey River hydrograph analysis**
 - **Flow dependent protected entities**
 - **Floodplain entities and transect findings**
 - **Aquatic entities and MesoHABSIM findings**
 - **Water supply**
 - **Final recommendations**

PISF Generalized Process

PISF Study

- Define protection goals
- Assess river conditions
- Define conditions to meet goals
- Establish numerical flow standards

WMP

- Evaluate problem reaches
- Evaluate management options
- Integrate options into a plan
- (Implement plans)

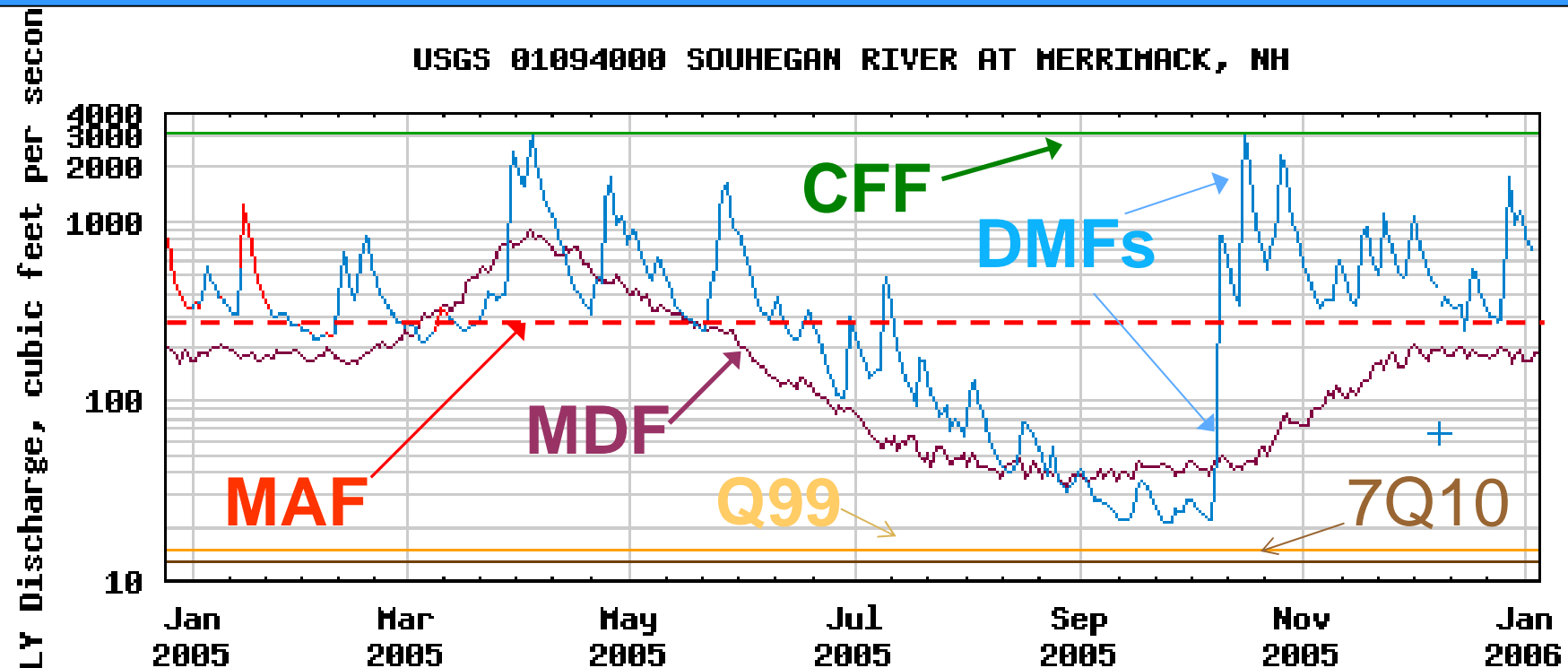
Some Protected Entities (Goals)

-
- ```
graph LR; HU[Human uses] --> HU_Goals[Recreation, HE energy production, Agriculture]; BI[Biological Integrity] --> BI_Goals[Natural resources, Storage, Wildlife, Fish & wildlife habitat, Vegetation, Rare species or habitat, Aquatic life and fish]
```
- **Human uses**
    - Recreation
    - HE energy production
    - Agriculture
  - Cultural uses
  - Water quality
  - Pollution
  - **Biological Integrity**
    - Natural resources
    - Storage
    - Wildlife
    - Fish & wildlife habitat
    - Vegetation
    - Rare species or habitat
    - Aquatic life and fish
  - Aesthetics
  - Fisheries
  - Public water supply
  - CWA Designated Uses
  - Open space
  - Geologic resource

## **What is Needed to Describe PISFs?**

- **A systematic method of determining flow needs for human uses.**
- **A systematic method of determining flow needs for ecological integrity.**
- **A meaningful way to describe stream flow and protected flows.**

# How to Describe the PISF?



- EXPLANATION -----
- MEDIAN DAILY STREAMFLOW BASED ON 70 YEARS OF RECORD
  - DAILY MEAN DISCHARGE
  - ESTIMATED STREAMFLOW
  - + Flow at station affected by ice
  - 2-Year Recurrence Interval
  - 99% Flow duration
  - 7-day, 10-year low flow

# Natural Flow Paradigm

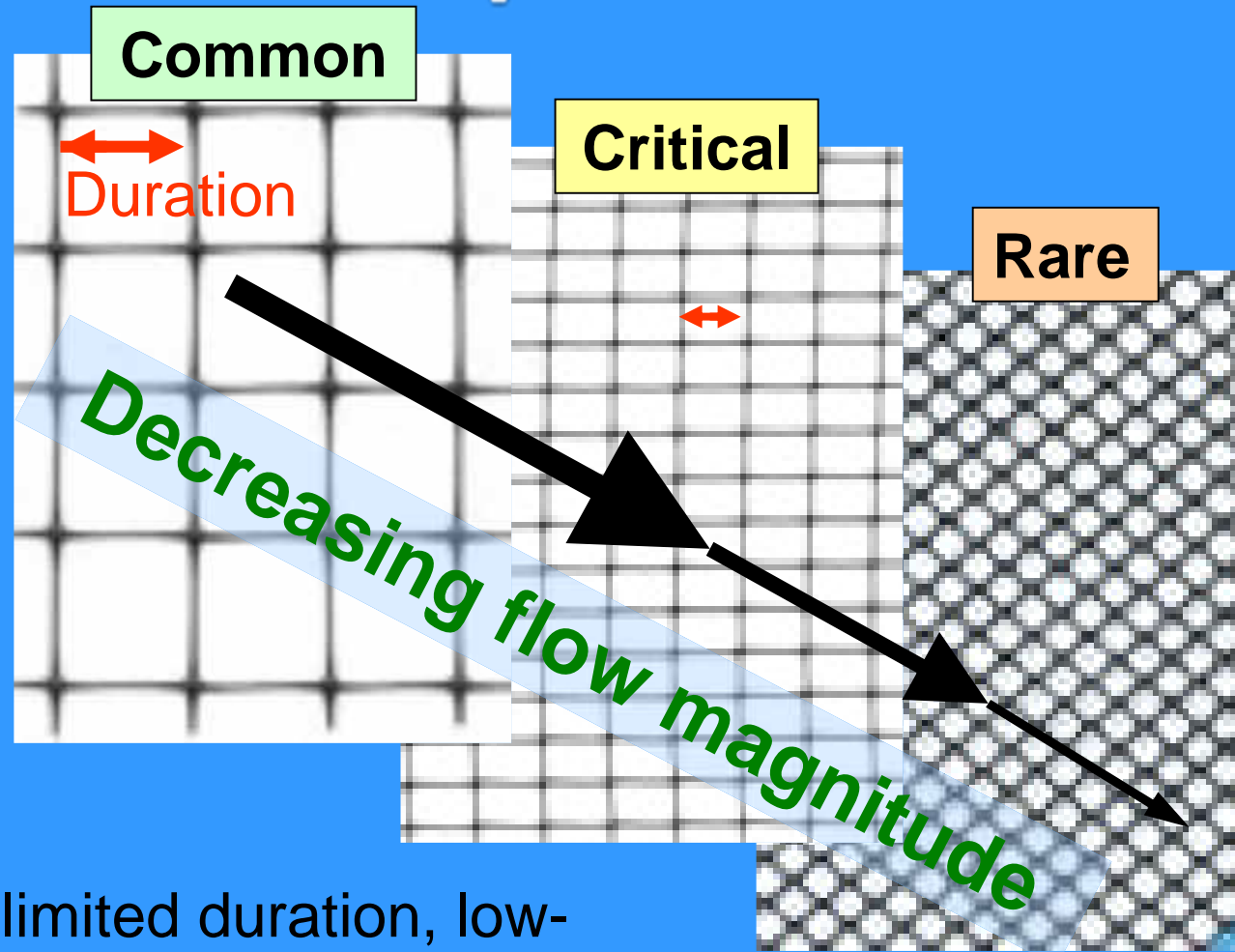
- NFP = aquatic life is adapted to naturally occurring variability.
- How to define the appropriate variability pattern for PISF?
- Describe flow as; **timing, duration, frequency, rate of change** as well as **magnitude**.

Poff NL, et al. 1997. The natural flow regime. A paradigm for river conservation and restoration. *BioScience* 47: 769–784.

## **How NFP flow components are described in the Lamprey PPISF report**

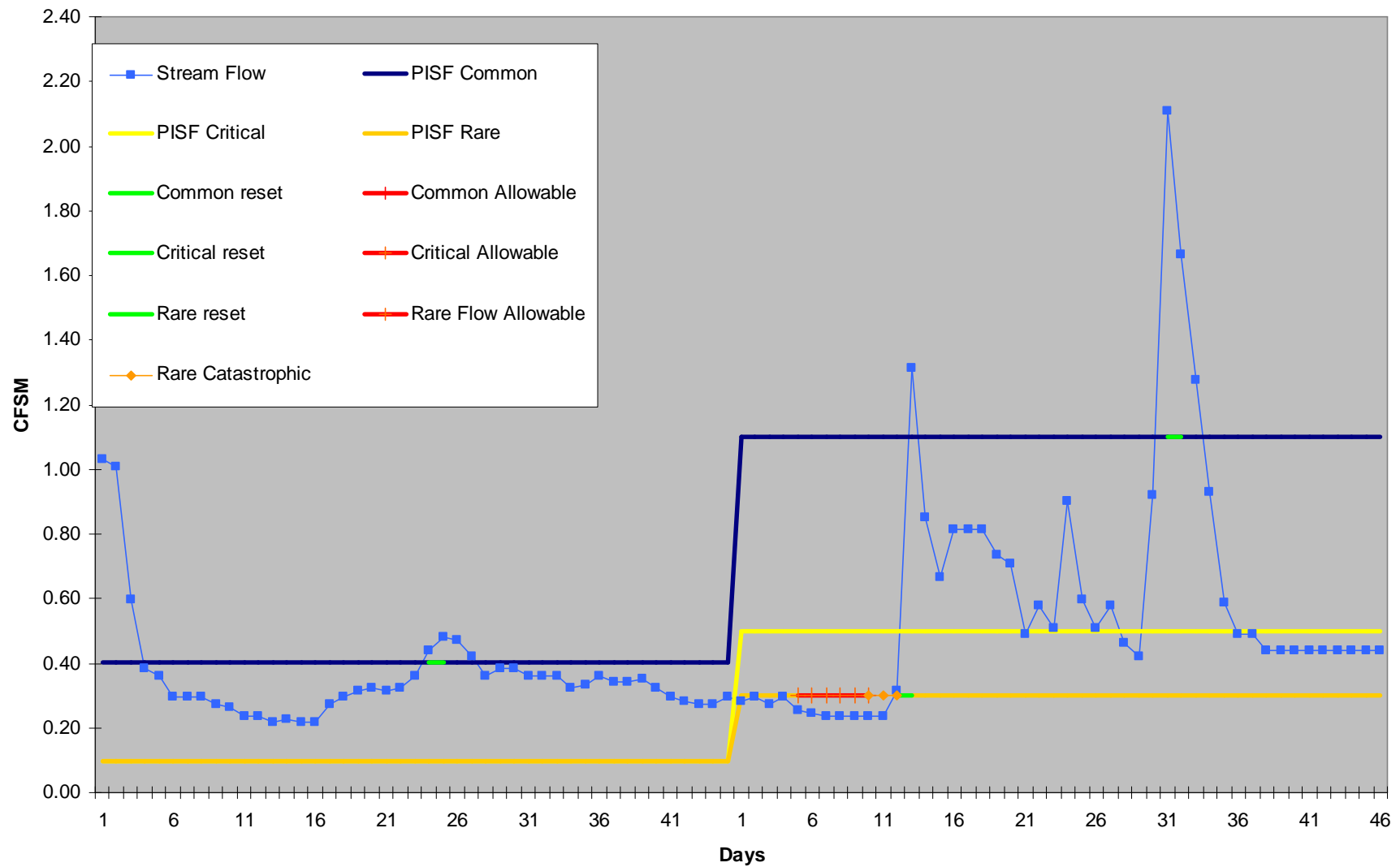
- **TIMING** – Bioperiods – biologically significant divisions of the year.
- **MAGNITUDE** – three levels for each bioperiod.
- **DURATION** – for each magnitude - allowable and catastrophic thresholds marking when flows go too low for too long.
- **FREQUENCY** – used either to 1) define the duration, or 2) specified number of events for magnitudes.

# Pair magnitudes with their natural durations at historically-significant frequencies



Lets only limited duration, low-flows get through

## Souhegan River Stream Flow versus PISF magnitude and durations



# Lamprey Hydrograph Analysis

- UNH reviewed discharge records (1934 – 2007) for the USGS gaging station (#01073500) at Packers Falls.
- Analyzed for trends. Reduction in August flows following change in Pawtuckaway Lake release policy in 1950s. Used post 1955 flow data for development of hydrographs.
- Created pre-development hydrographs by adding in permitted consumptive water use (DES data) and correcting for Pawtuckaway Lake releases and filling.

# **Lamprey Hydrograph Analysis**

- **3-yr (wet, average and dry) and 5-yr records (last 5 yrs) were developed in accordance with project tasks.**
- **30-yr record (1976 – 2005) used for development of PISF.**

# Lamprey Flow Measurements

- UNH measured concurrent instantaneous flows at Wadleigh Falls and Packers Falls 16 times (flows of 0.06 to 1.64 cfs).
- Correlated concurrent flow measurements to instantaneous flows at the USGS gaging station at the same times:

$$Q_{\text{upstream, cfs}} = a Q_{\text{USGS}}$$

- 3-yr (wet, average and dry), 5-yr (last 5 yrs), and 30-yr hydrographs then developed the same for Wadleigh and Packers Falls.

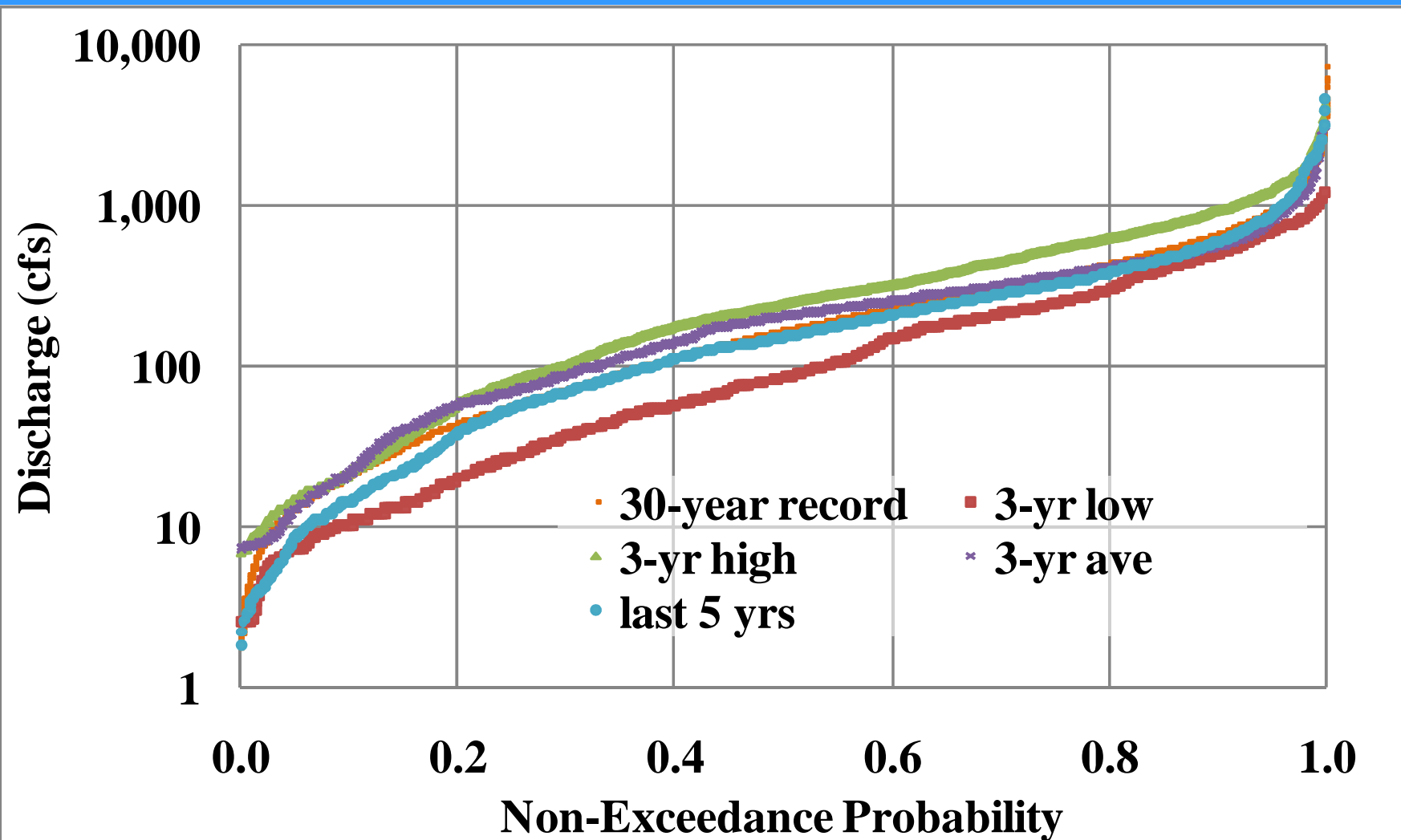
# Regression Results

Concurrent flows correlated with instantaneous flows at USGS gaging station using regression.

| Site Description | Area (mi <sup>2</sup> ) | Ratio to USGS gage | Num. of Measures | a      | R <sup>2</sup> |
|------------------|-------------------------|--------------------|------------------|--------|----------------|
| Wadleigh Falls   | 135                     | 0.738              | 16               | 0.7849 | 0.998          |
| Lee Hook Road    | 161                     | 0.880              | 16               | 0.8813 | 0.9902         |
| USGS Gage        | 183                     | 1.000              | N/A              | N/A    | N/A            |

Results show that Q can be estimated based on ratio of watershed area upstream of point to USGS gage.

# Flow Duration of Selected Records



# Lamprey Hydrograph Analysis

Once PISF were developed:

- the three year,
- five year, and
- 30 year

stream flow records were evaluated to identify the statistical occurrences of when the river does not meet the PISF for each affected water user (AWU) location.

**MORE ABOUT THIS LATER!**

# Flow Dependent Protected Entities

INSTREAM PUBLIC USES, OUTSTANDING  
CHARACTERISTICS, AND RESOURCES OF THE LAMPREY  
RIVER AND PROPOSED PROTECTIVE FLOW MEASURES FOR  
FLOW DEPENDENT RESOURCES

*FINAL REPORT*

NOVEMBER 2006



# **Flow Dependent Protected Entities**

**Evaluation of flow dependent instream public uses, outstanding characteristics and resources (IPUOCR) aka Protected Entities.**

**Protected Entity categories:**

- Recreation**
- Maintenance and Enhancement of Aquatic Fish and Life**
- Fish and Wildlife Habitat**
- Rare, Threatened and Endangered Species or Natural Ecological Communities**
- Public Water Supply**

# Flow Dependent Protected Entities

## Recreation

- Boating
- Fishing
- Swimming

## Natural Communities

- Floodplain Forests
- Oxbow/backwater Wetlands
- Vernal Pools
- High Energy Riverbanks
- River Rapids

## RTE Plants

- Water Marigold
- Sharp-flowered Mannagrass
- Knotty Pondweed
- Small-crested Sedge
- Slender Blue Flag
- Climbing Hempweed

## RTE Wildlife

- Wood Turtle
- Spotted Turtle
- Blanding's Turtle
- Pied Billed Grebe
- Osprey
- Bald Eagle
- Sedge Wren

## Aquatic Life and Habitat

- Fish and Fish Habitat
- Mussels
- Insects
- T/E Bridled Shiner
- Banded Sunfish
- Endangered Brook Floater

## Public Water Supply

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## Public Water Supply

# Recreation

## Recreation Protected Entities:

- Boating
- Fishing
- Swimming

All noted as important resources in the documents submitted to DES applying for designation in 1990.

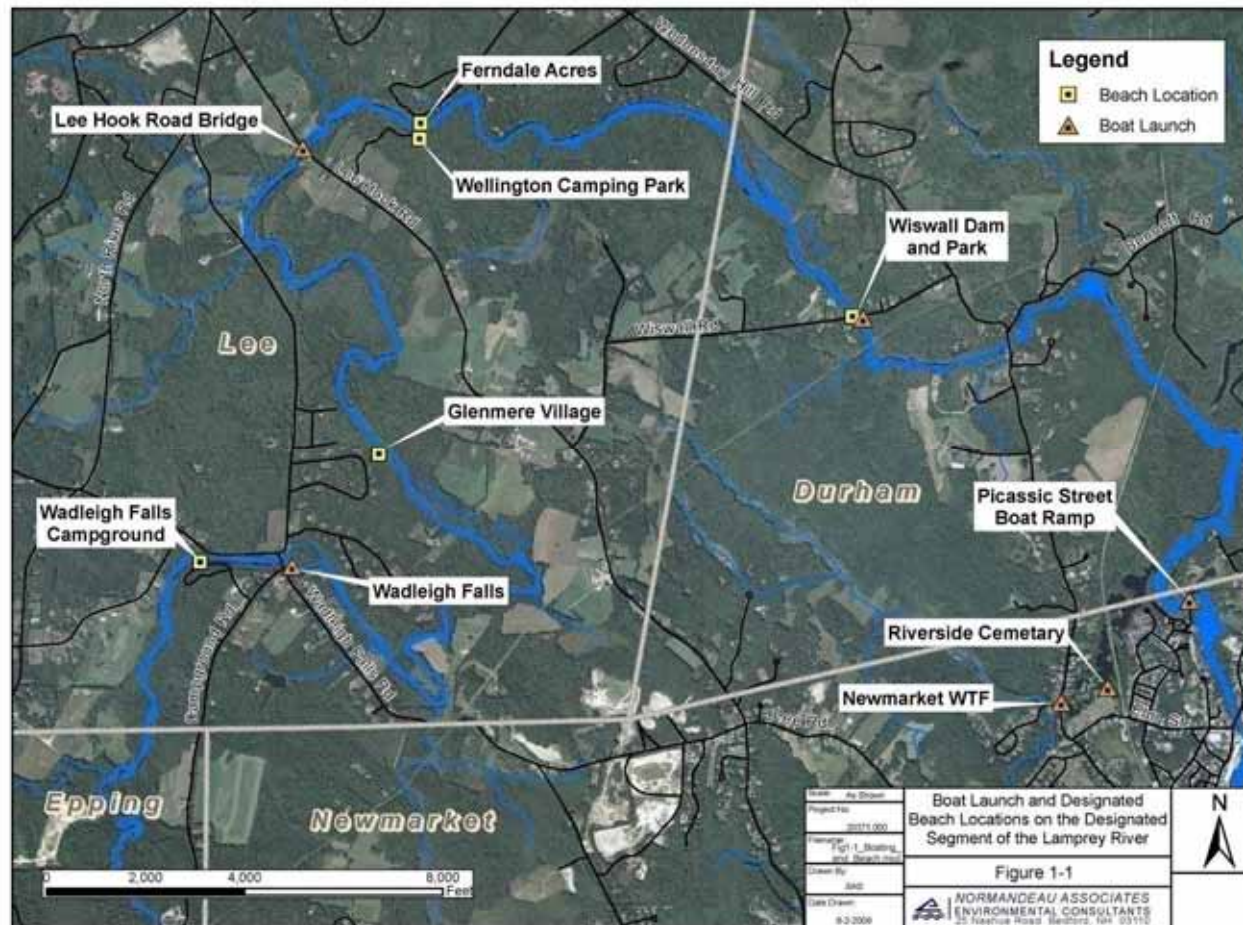
# Recreation - Boating



## **Recreation - Boating**

- **Evaluated by field surveys (including swimming survey).**
- **Surveys performed in spring, summer and fall of 2006 and spring 2007.**
- **Surveyed participants of 2006 Lamprey River Canoe (& Kayak) race.**
- **Visited popular boat launch locations on upper and lower portions of the designated segment.**

# Recreation - Boating



# Recreation - Boating

Flatwater upstream of:

- Wadleigh Falls
- Lee Hook Road
- Wiswall Dam
- Packers Falls
- Macallen Dam



# Recreation - Boating

Rapids at or below:

- Wadleigh Falls
- Lee Hook Road
- Wiswall Dam
- Packers Falls



# Recreation - Boating

Lamprey River Flow (USGS gage at Packers Falls) for survey dates:

|                    | Mean<br>Daily Discharge |             | Historical<br>Mean Discharge |
|--------------------|-------------------------|-------------|------------------------------|
| <u>Survey Date</u> | <u>CFS</u>              | <u>CFSM</u> | <u>(CFS)</u>                 |
| April 16 2006      | 185                     | 1.01        | 698                          |
| April 29 2006      | 154                     | 0.84        | 477                          |
| July 1 2006        | 249                     | 1.36        | 127                          |
| July 3 2006        | 177                     | 0.97        | 292                          |
| July 20 2006       | 100                     | 0.55        | 80                           |
| Oct. 8 2006        | 64                      | 0.35        | 99                           |
| May 26 2007        | 353                     | 1.93        | 322                          |

# Boating Survey Results

## Upper Lamprey (Not Designated):

- Most paddle 1-2 times a year, usually spring.
- Paddlers from southern NH, also MA + ME.
- Monitor flow by word of mouth or visual.
- Typically paddle from Blair Park to Rte 87.
- Minimum flow should be higher than on April 16 and 29 2006 (0.8 to 1.0 cfsm).
- Attraction of river: wildlife, feeling of remoteness, beautiful scenery, variable paddling conditions.

# Boating Survey Results

## Lower Lamprey (Designated):

- Most paddle more than 2 times a year, during spring, summer and fall.
- Paddlers from Durham and Dover NH.
- Monitor flow by word of mouth or visual.
- Paddle flatwater sections upstream of falls or dams.
- Minimum flow should be about what was observed on July 1 2006 (1.4 cfs).
- Attraction of river: quiet, lack of development, beautiful scenery and fishing.

# Recreation - Boating

Other sources of information on recommended flow levels for paddling Lamprey River:

- AMC Guidebook Discover Southern New Hampshire by Monkman and Monkman (2002) suggests that running the Lamprey at flows below 200 cfs (1.09 cfs) should not be attempted.
- Survey respondents from 2006 Lamprey Canoe Race indicated that flows should have been higher than what they were (154 cfs, 0.84 cfs) the day of the race.

# **Recreation - Boating**

**Other sources of information on recommended flow levels for paddling Lamprey River:**

- Indicator of water level – flow over rapids/riffles downstream of Lee Hook Road Bridge. If you can pass this with a canoe, whole trip usually good.**
- Passage of canoes and kayaks through rapids downstream of Lee Hook Road bridge observed in April and May 2008 at flows of 425 and 205 cfs.**

# Recreation - Boating



July 12 2007  $Q = 150$  cfs



May 14 2008  $Q = 205$  cfs



March 13 2007  $Q = 323$  cfs



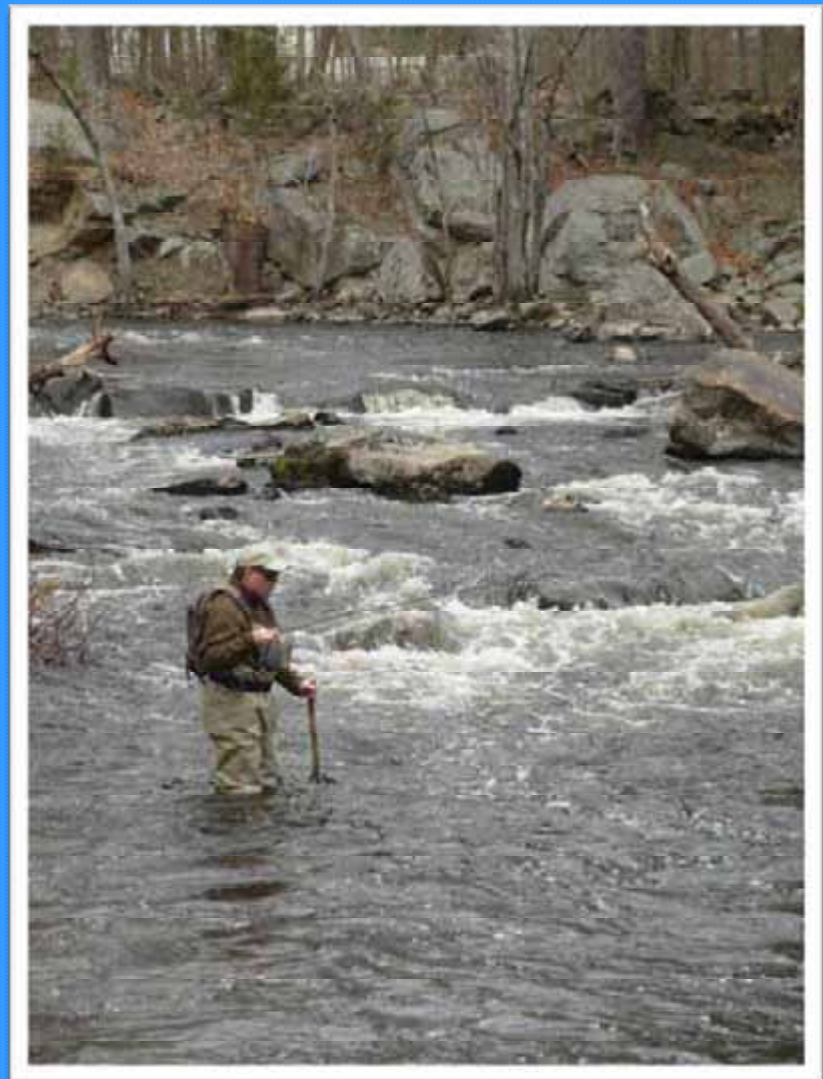
April 19 2008  $Q = 425$  cfs

# Recreation - Boating

## Protected Instream Flow for Recreational Boating:

- Paddling through rapids flow dependent, flatwater paddling not flow dependent, but levels controlled naturally or artificially.
- Observed flow conditions at rapids sections suggest flows greater than 200 cfs (1.1 cfs) needed to navigate rapids.
- Based on field crew observations a flow of 275 cfs (1.5 cfs) proposed as PISF for whitewater recreational boating.

# Recreation - Fishing



# Recreation - Fishing

## Report discusses:

- Location of popular fishing spots along the designated segment.
- Coldwater and warm water fishing resources.
- Issue of anadromous fish passage.
- NH Fish and Game Department management program and Trout Unlimited fish stocking.
- Fishing on the Lamprey is flow dependent, but the instream flows required to maintain the fish habitat will be adequate to preserve fishing on the river. So a recreational fishing study was not performed.

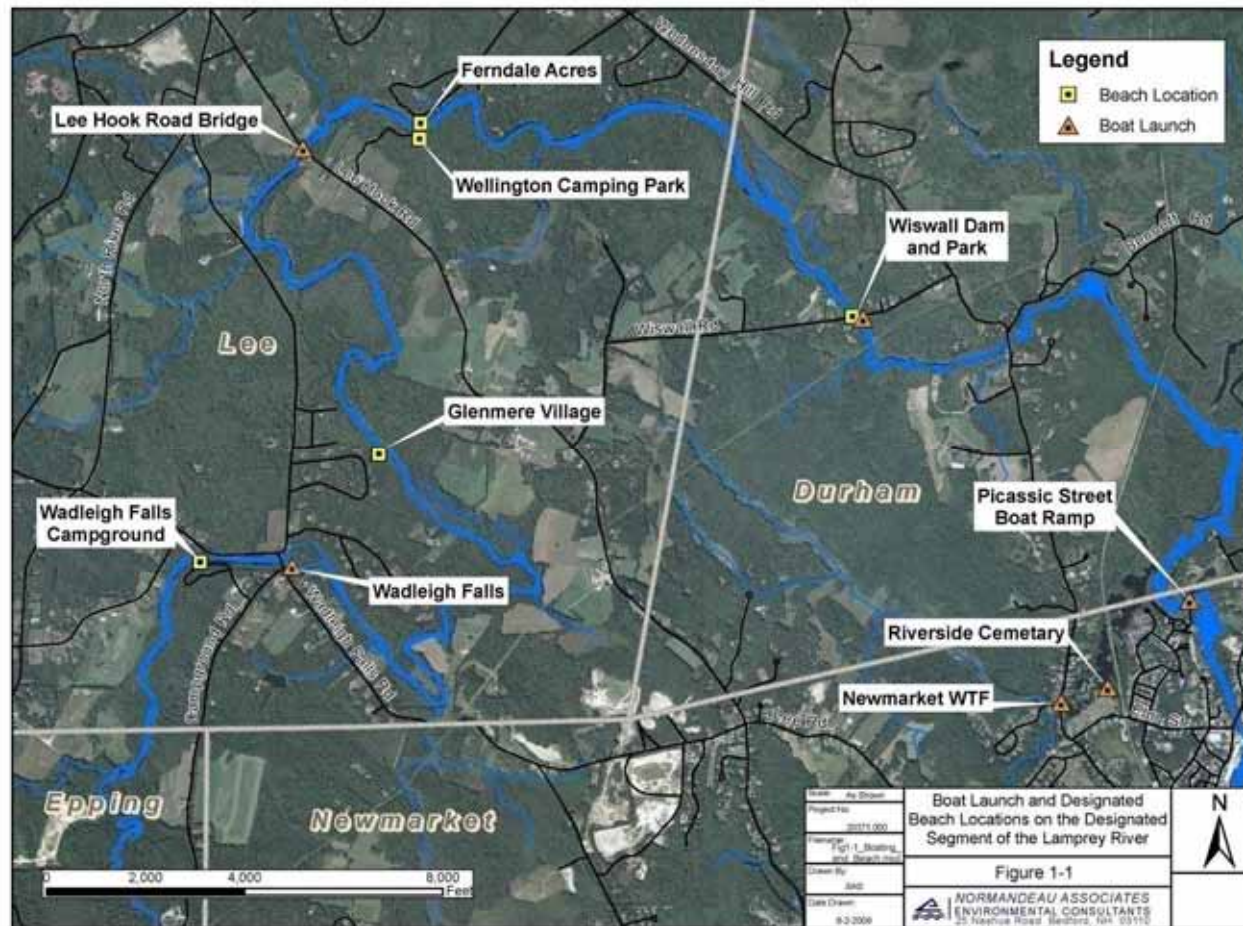
# Recreation - Swimming



## **Recreation - Swimming**

- **Swimming popular recreational activity at designated beaches and swimming holes along the Lamprey River.**
- **Recreational swimming assessed by surveys performed at four designated beaches and two swimming holes.**
- **Interviews were conducted on July 29 and August 5, 2006.**

# Recreation - Swimming



# **Swimming Survey**

**The survey included questions regarding:**

- Use of the river**
- Frequency of use**
- Favorite swimming locations**
- Preferred flow conditions or levels,  
sources of information on swimming  
conditions.**

# Swimming Survey

- One location did not have a usable beach (Glenmere).
- Two of the locations have both a beach and a pool (Ferndale and Wadleigh).
- The three campgrounds restricted access to beach and/or pool to registered campers and daily guests (paid pass required).

# Swimming Survey Results

- Months of use ranged from April to October, most activity centered June to August during periods of hot weather.
- Few people monitor flow conditions other than by driving by or checking when they arrive at their campsite.
- Outside of large-scale drought or flood events, swimmers will use the river when it is convenient and it is warm enough.

## **Recreation - Swimming**

- **Most popular sections of river used for swimming are impounded by dams or bedrock falls.**
- **Due to control of water levels in these sections, they are less flow dependent than in other sections and for other recreational uses.**
- **Since swimming conditions are dependent on multiple variables a specific instream flow value cannot be established or proposed.**

# Flow Dependent Protected Entities

## Recreation

- Boating
- Fishing
- Swimming

## Natural Communities

- Floodplain Forests
- Oxbow/backwater Wetlands
- Vernal Pools
- High Energy Riverbanks
- River Rapids

## RTE Plants

- Water Marigold
- Sharp-flowered Mannagrass
- Knotty Pondweed
- Small-crested Sedge
- Slender Blue Flag
- Climbing Hempweed

## RTE Wildlife

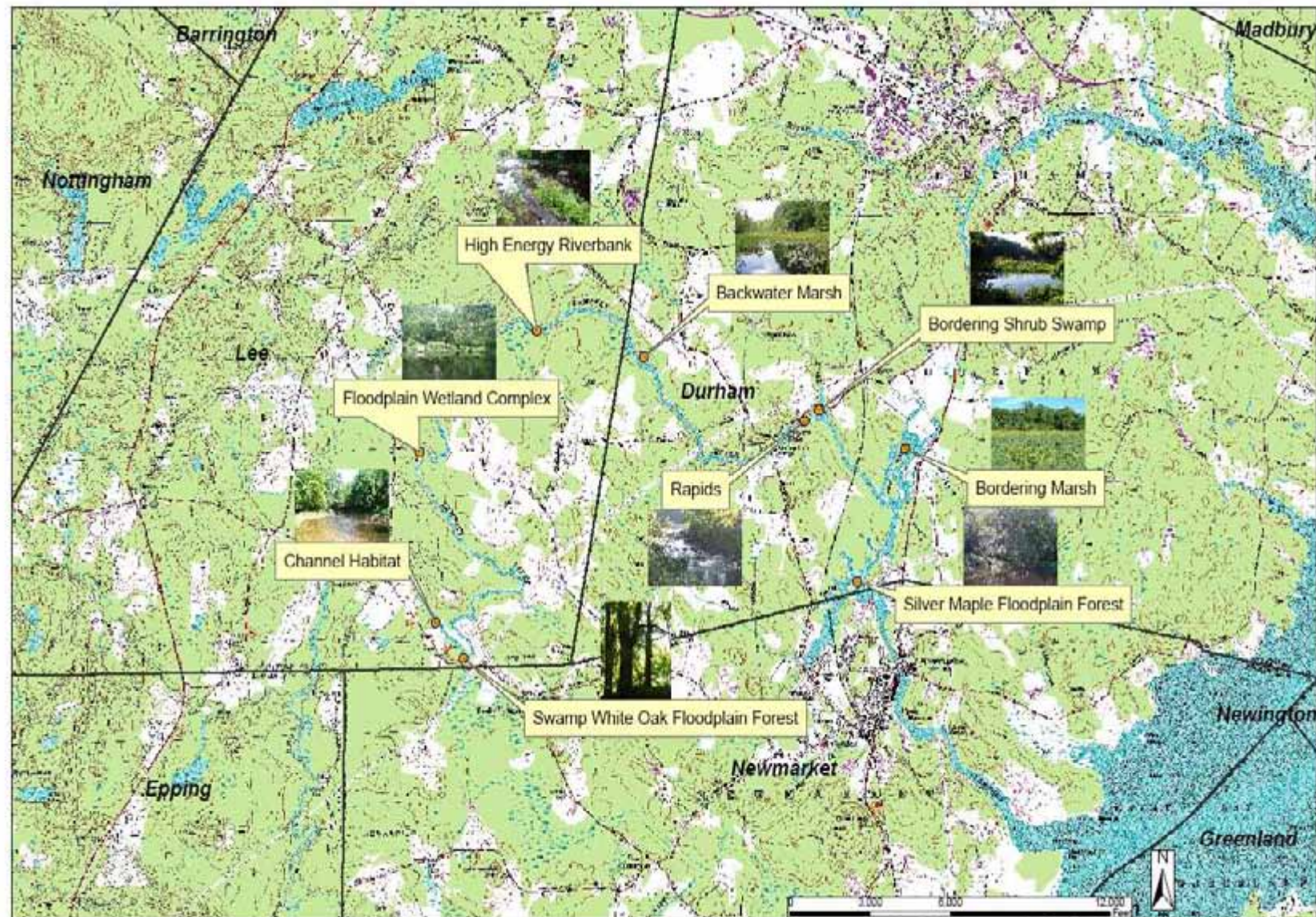
- Wood Turtle
- Spotted Turtle
- Blanding's Turtle
- Pied Billed Grebe
- Osprey
- Bald Eagle
- Sedge Wren

## Aquatic Life and Habitat

- Fish and Fish Habitat
- Mussels
- Insects
- T/E Bridled Shiner
- Banded Sunfish
- Endangered Brook Floater

## Public Water Supply

# Plant Communities/Wildlife Habitat



# Associated Flora and Fauna

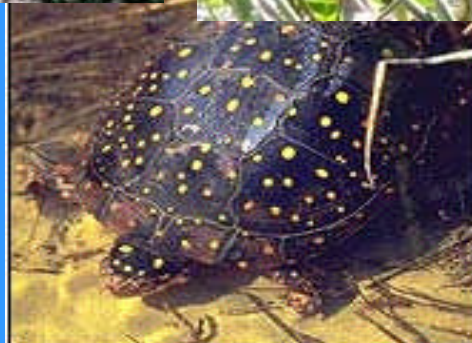
## RTE, SC, SGCN, Others



Photo by Greg Lasley



Peter S. Weber



# Floodplain Forests and Pools

(Low Energy/Above Channel)

Periodic flooding (1-100 years) – early spring



## Sensitive Resources:

- Swamp White Oak, Red Maple, Silver Maple Floodplain Forests
- Ground-nesting turtles and birds
- VP breeders/feeders
- Slender Blueflag Iris

# Oxbow/Backwater/Fringe Wetlands (Low Energy/Channel)

Channel margins, pools, tributaries & oxbows

Permanent inundation to seasonal saturation

Variable flow dependence – dams, levees,  
tribs



## Sensitive Resources:

- Overwintering Blanding's/Spotted Turtles
- Nesting Birds - Pied-billed Grebe/Sedge Wren
- Water Marigold/Star Duckweed/Climbing Hempweed
- Invertebrates/larval amphibians





## Riverbanks and Rapids (High Energy)

Continuous to seasonal  
inundation

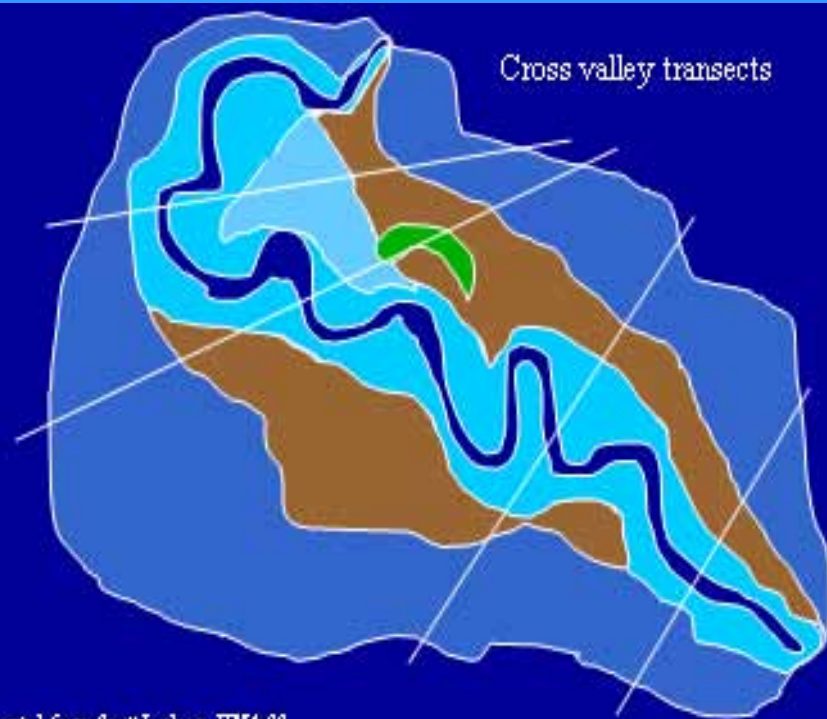
Seasonal ice and flood scour

### Sensitive Resources:

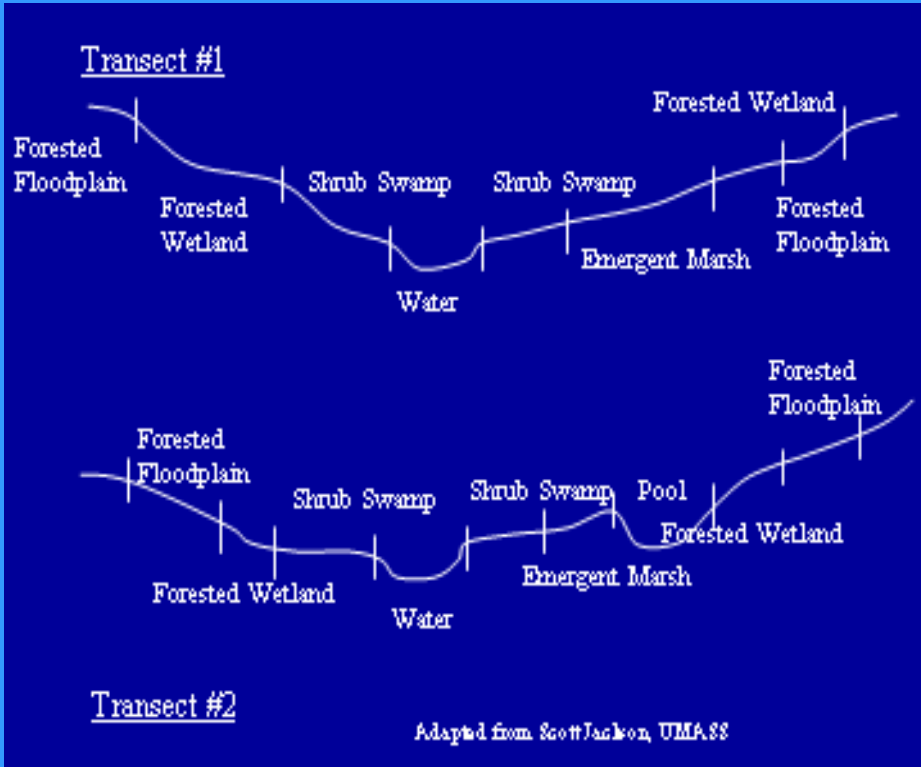
- Herbaceous Low Riverbank Community
- Riverweed Rapid Community
- Sharp-flowered Mannagrass
- Knotty Pondweed
- Aquatic macroinvertebrates



# Transect Method

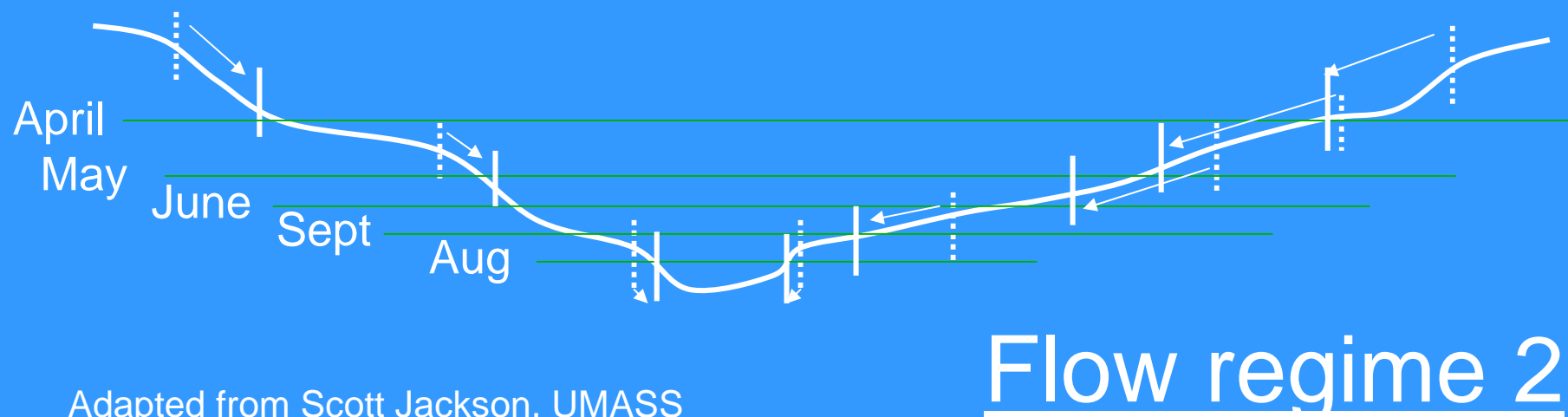
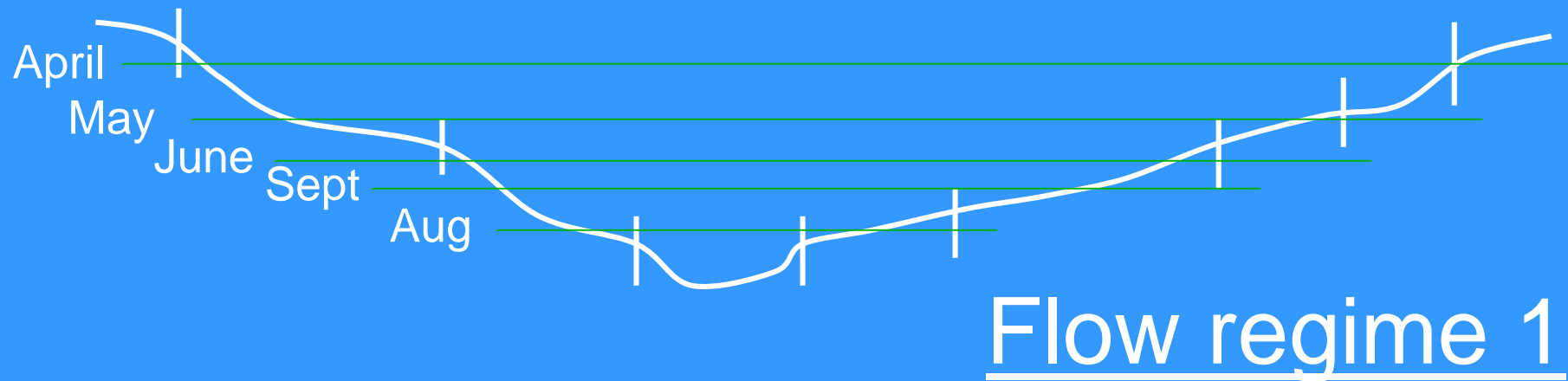


Adapted from Scott Jackson, UMASS



Adapted from Scott Jackson, UMASS

# Transect #1



Adapted from Scott Jackson, UMASS

# Change in Area

Forested  
Floodplain

Forested  
Wetland

Shrub swamp

Shrub swamp

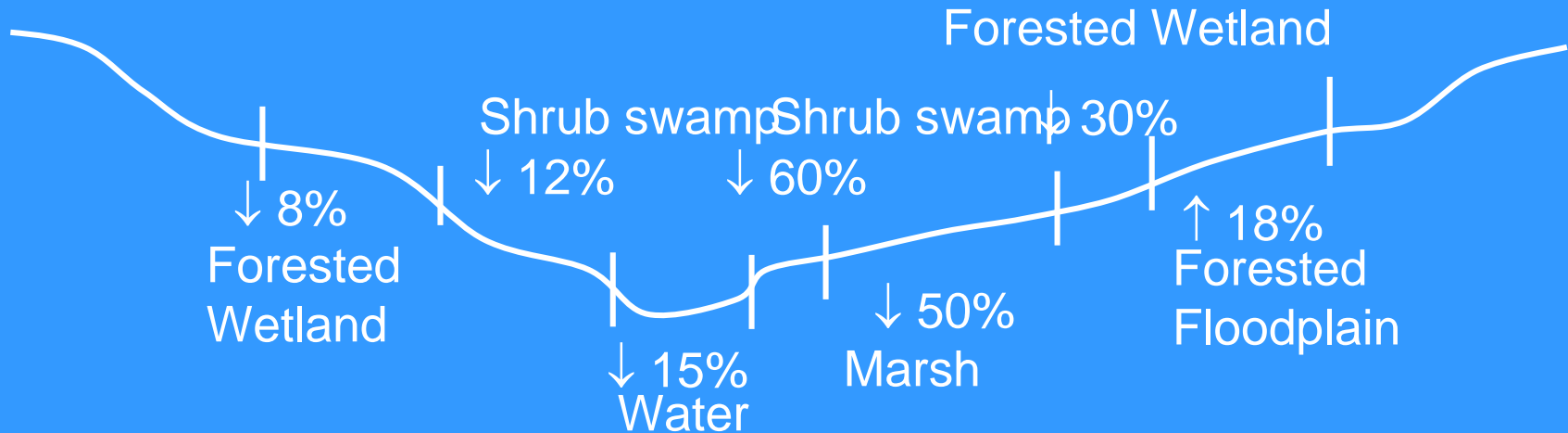
Forested Wetland

Forested  
Floodplain

Emergent Marsh

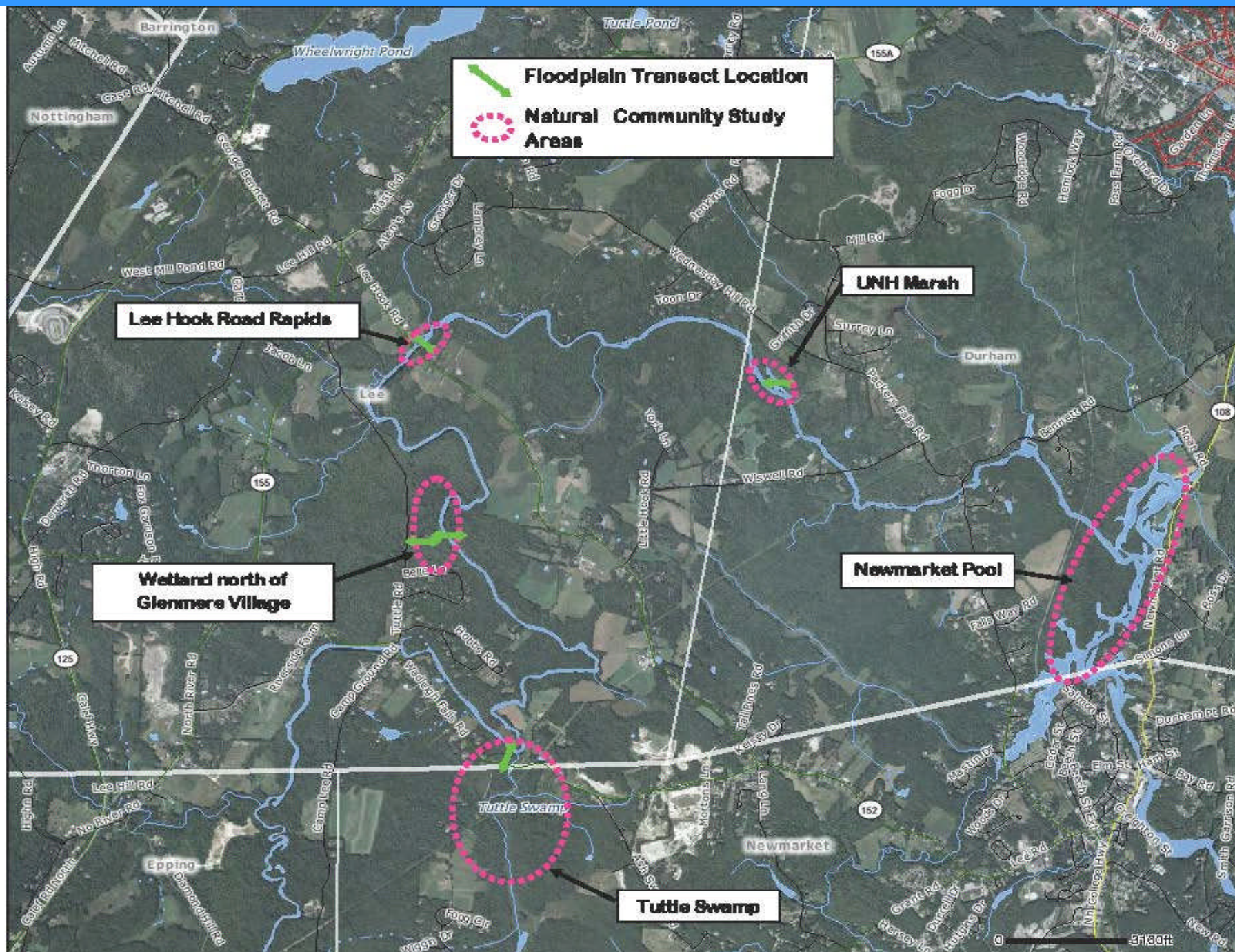
Water

Flow regime 1



Flow regime 2

Adapted from Scott Jackson, UMASS



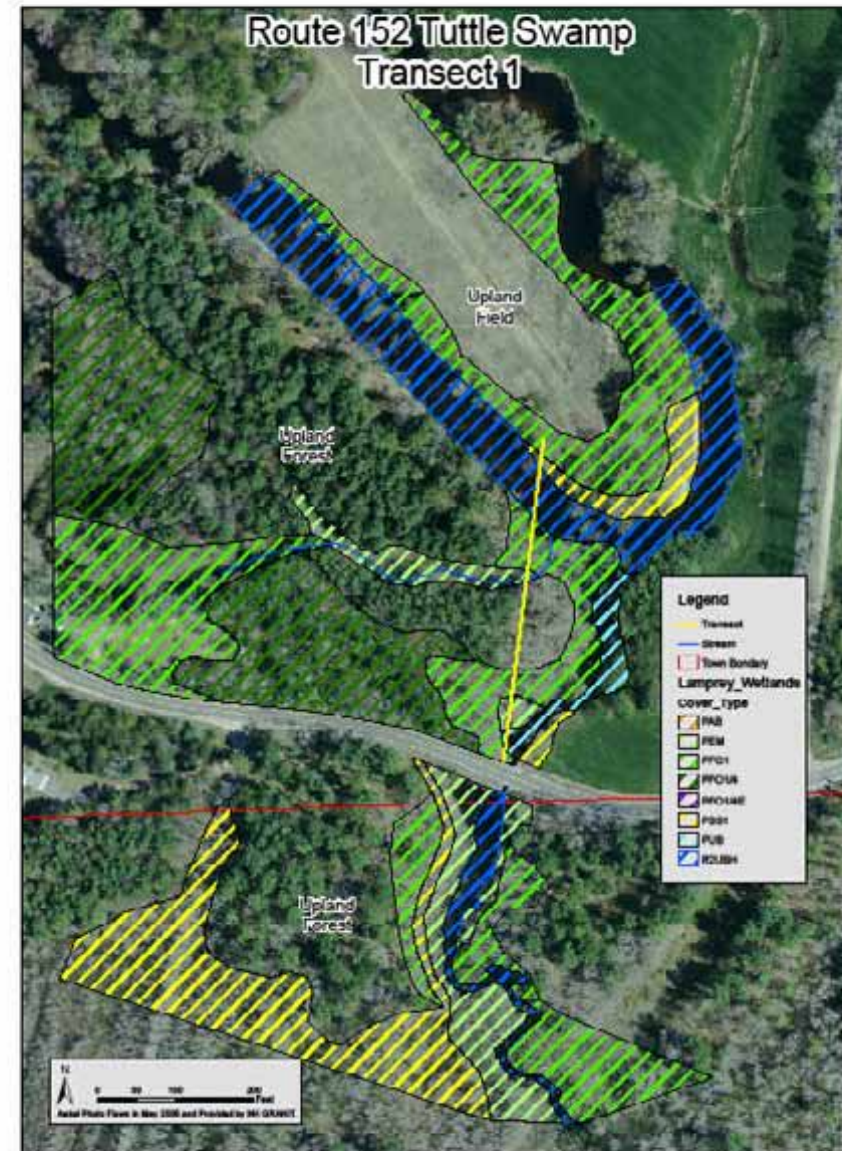




## T-1 Tuttle Swamp

### Protected Entities

- Exemplary Swamp White Oak Floodplain Forest
- Silver Maple Floodplain
- Backwater Swamp
- RTE Plant – Knotty Pondweed
- Wildlife Habitat

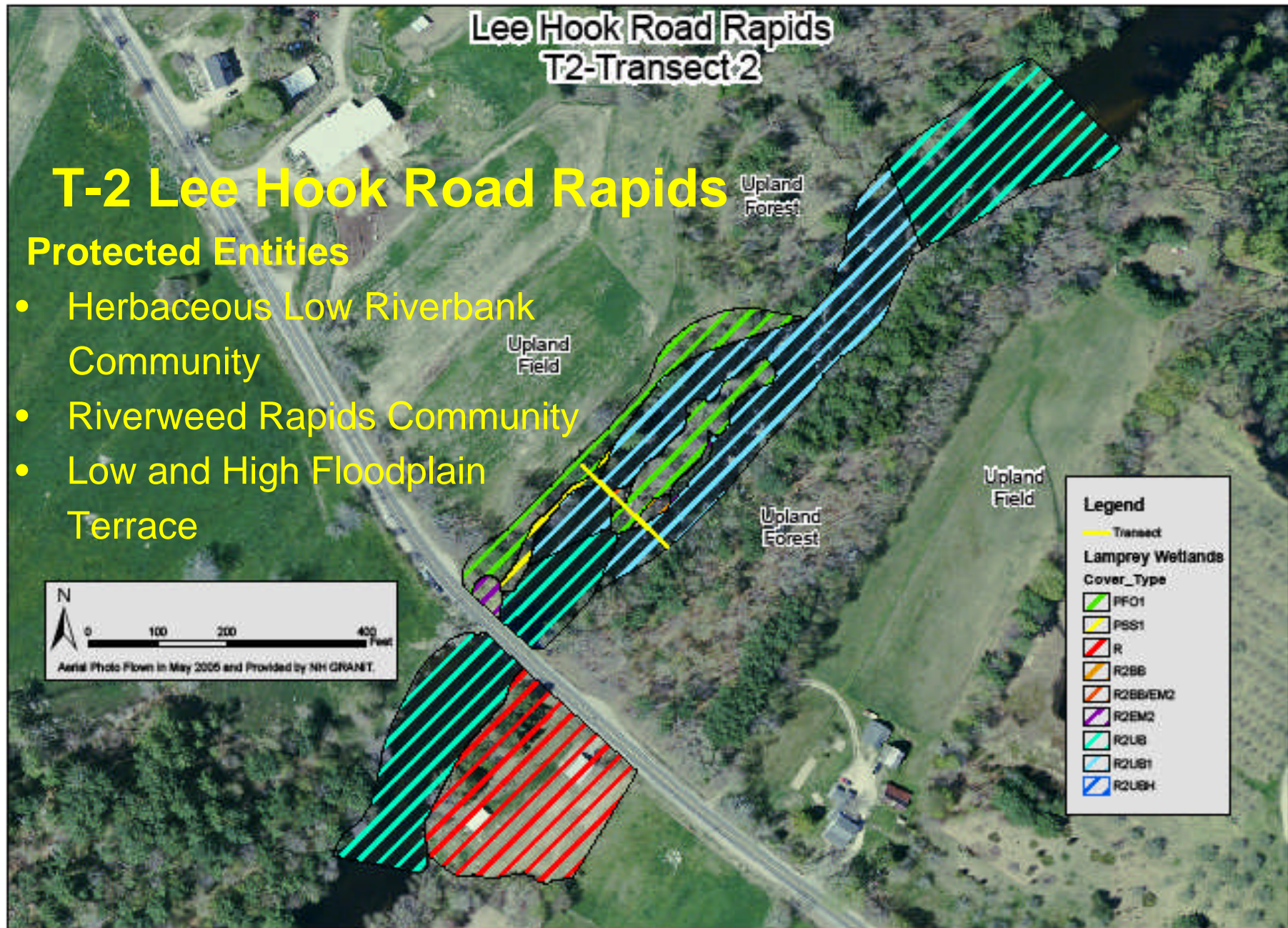


## Lee Hook Road Rapids T2-Transect 2

### T-2 Lee Hook Road Rapids

#### Protected Entities

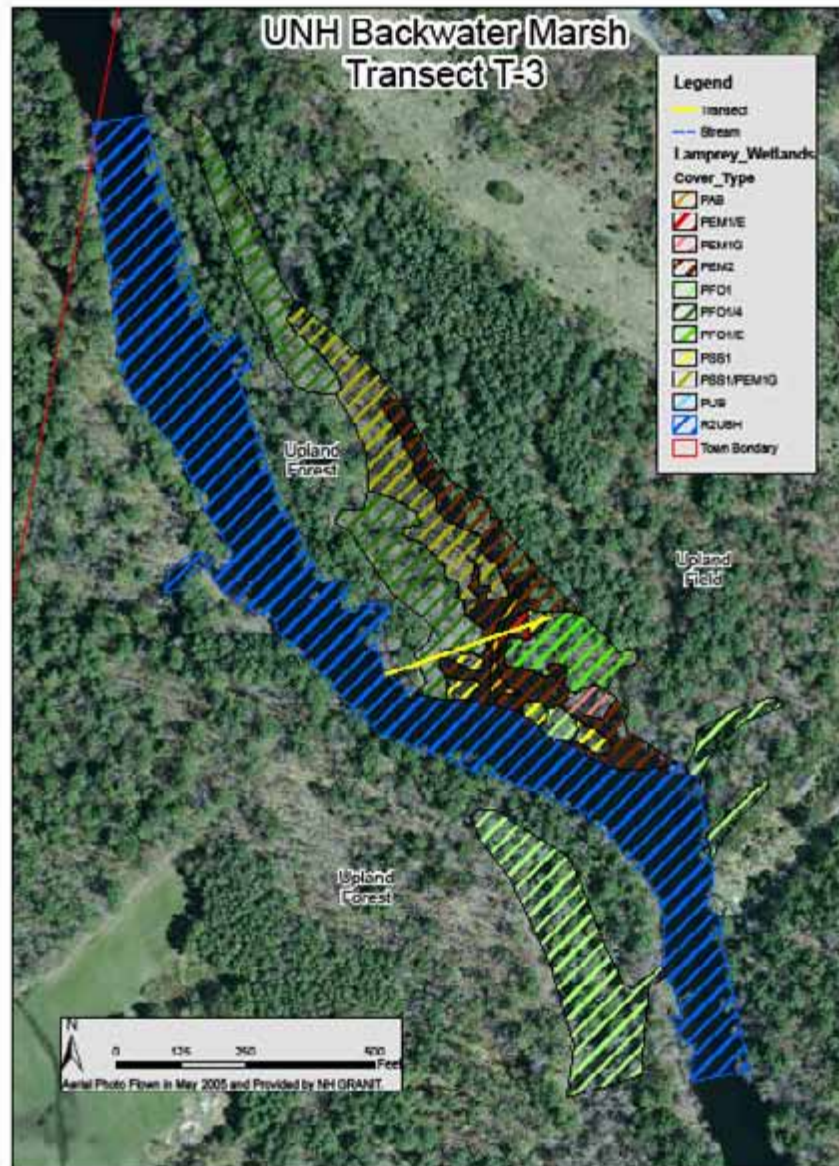
- Herbaceous Low Riverbank Community
- Riverweed Rapids Community
- Low and High Floodplain Terrace

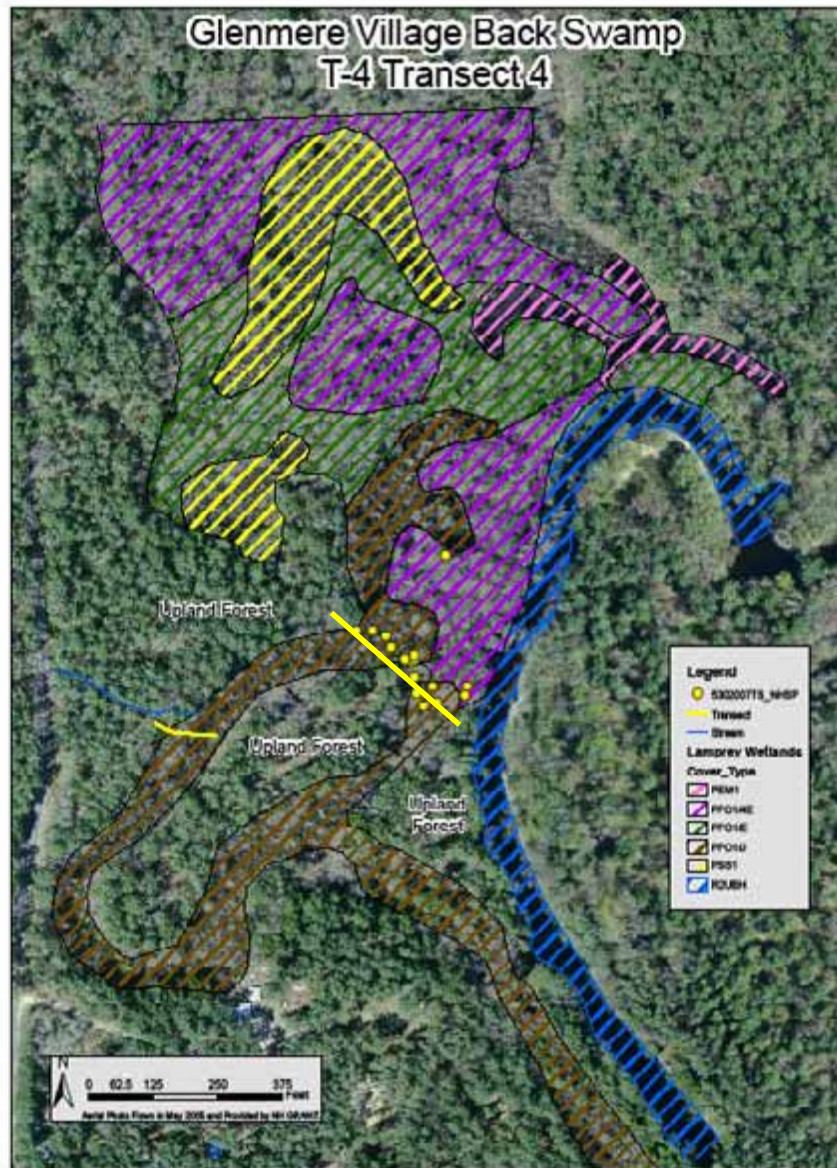


# T-3 UNH Marsh

## Protected Entities

- Marsh, Shrub and Forested Wetlands
- Silver Maple Floodplain Forest
- Wildlife Habitat – waterfowl, raptors, shorebirds, amphibians





## T-4 – Glenmere Swamp

### Protected Entities

- Vernal Floodplain Pools
- Red Maple/Oxbow Shrub Swamps
- High Floodplain Terrace
- Potential Spotted and Blanding's turtles
- Wildlife Habitat

# Moat Island Marsh

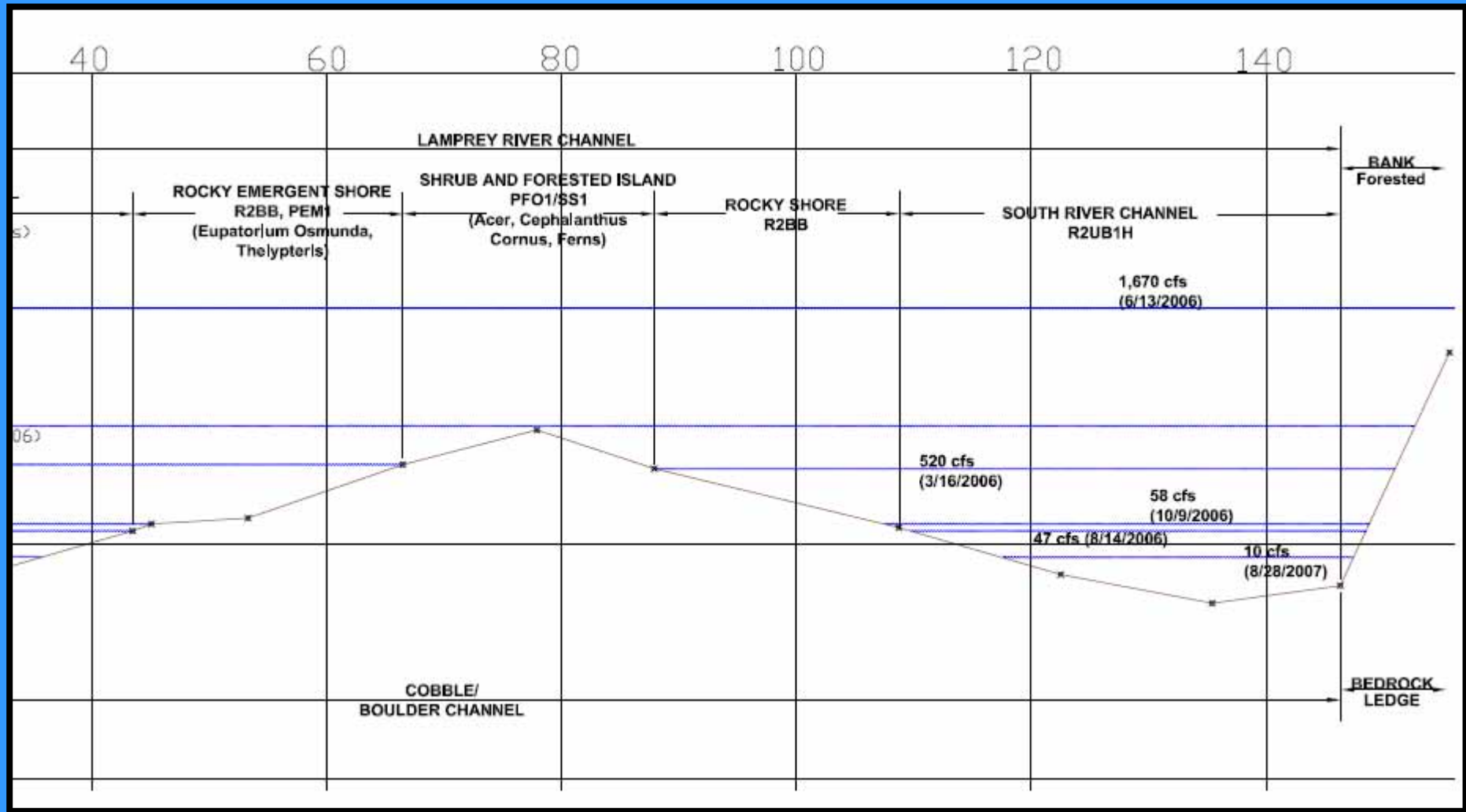


This location will be evaluated through aerial photo/digital elevation modeling only

- RTE Plants
- Pied-billed Grebe
- Waterfowl and Shorebird Habitat



## T-2 Lee Hook Road Rapids (excerpt)





August 28 2007  $Q = 10$  cfs



July 12 2007  $Q = 150$  cfs



March 13 2007  $Q = 323$  cfs



April 19 2008  $Q = 425$  cfs

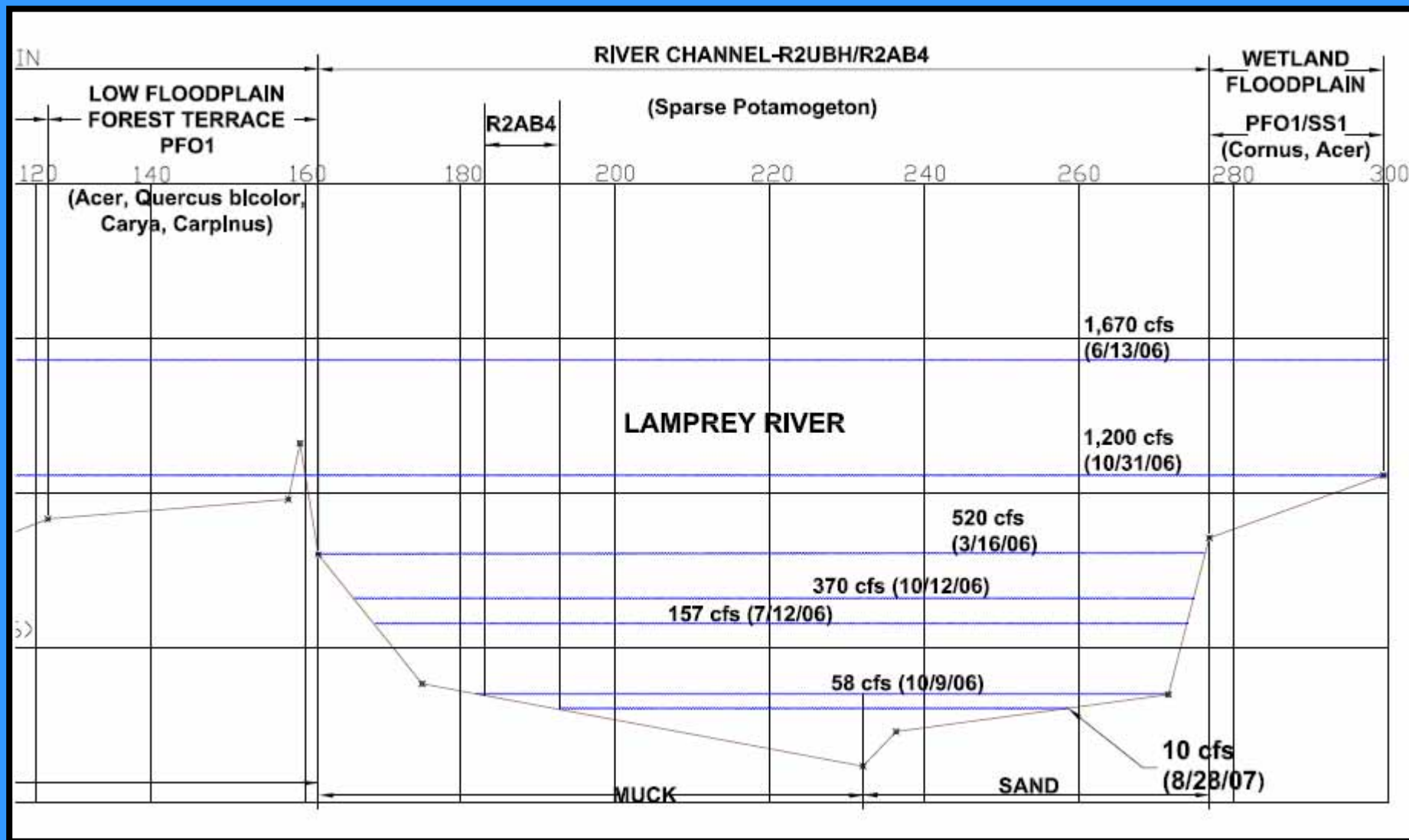


March 16 2006  $Q = 510$  cfs

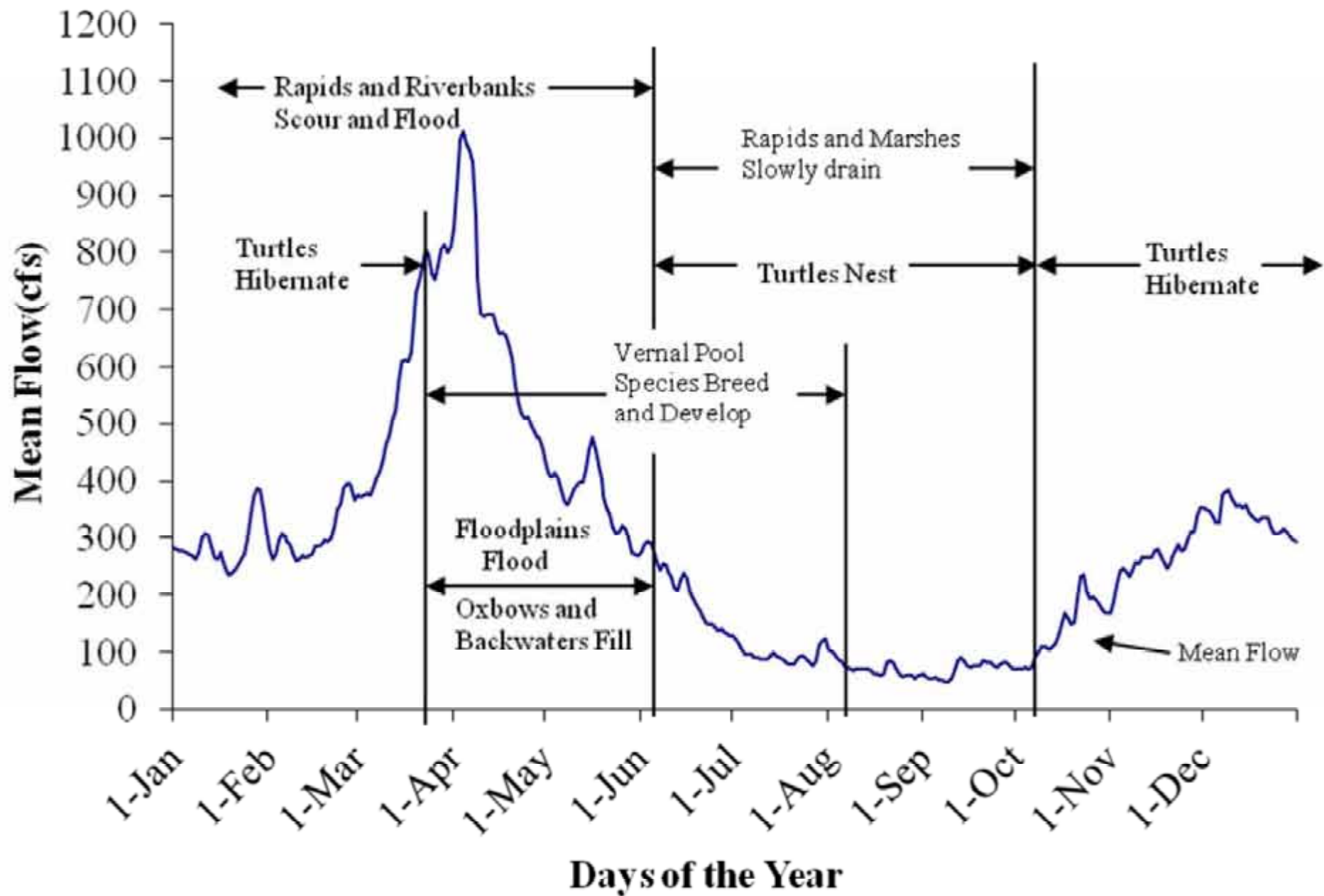


June 13 2006  $Q = 1,670$  cfs

# T-1 Tuttle Swamp Transect (excerpt)



## Wildlife and Natural Community Bioperiods



| Protected Entity                        | Sensitive Bioperiod(s)   | General Flow Requirements.                           | Preliminary PISF (at Gauge)                                               |
|-----------------------------------------|--------------------------|------------------------------------------------------|---------------------------------------------------------------------------|
| Low Floodplain Forest                   | Growing season           | 1-3 year flooding<br>( $< 2$ yr return flood)        | $>500$ cfs every 1-3 years<br>For 5-50 days                               |
| Herbaceous Low Riverbank                | Winter/Spring dormancy   | Flood/ice scour of channel                           | December 1 to April 30<br>500 cfs for 1 week                              |
| Deep and Shallow Marsh                  | Early-mid growing season | Flooding of marsh for dependent fauna                | April 1 to July 31<br>$>10$ cfs daily mean flow                           |
| Riverweed River Rapid                   | Spring growth            | Flooding of Riffles                                  | May 1 to June 30<br>$>100$ cfs mean monthly flow                          |
|                                         | Late summer flowering    | Low flow to expose riffles                           | August 1 to September 30<br>$< 100$ cfs mean monthly flow                 |
| Wood Turtle<br><i>Clemmys insculpta</i> | Spring-summer nesting    | No flooding during nesting in mid to high floodplain | June 1 to October 15<br>$<500$ cfs daily flow                             |
|                                         | Winter hibernation       | Avoid dewatering of in-channel hibernation sites     | December 1 to March 31<br>$>130$ cfs monthly mean<br>$>50$ cfs daily mean |

# Flow Dependent Protected Entities

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- Boating
- Fishing
- Swimming

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- Banded Sunfish
- Endangered Brook Floater

## Public Water Supply

# Lamprey River MesoHABSIM Application



# Lamprey River Watershed

## Legend

### Lamprey loggers

- Loggers Missing
- Loggers Recovered

Major Roads

lamprey\_river

### Watershed Elevations

feet

High : 348

Low : 0

Wetland

Lake/Pond

DL-17

DL-32

DL-32

DL-38

TL-21

DL-37

DL-43

DL-42

TL-22

DL-40

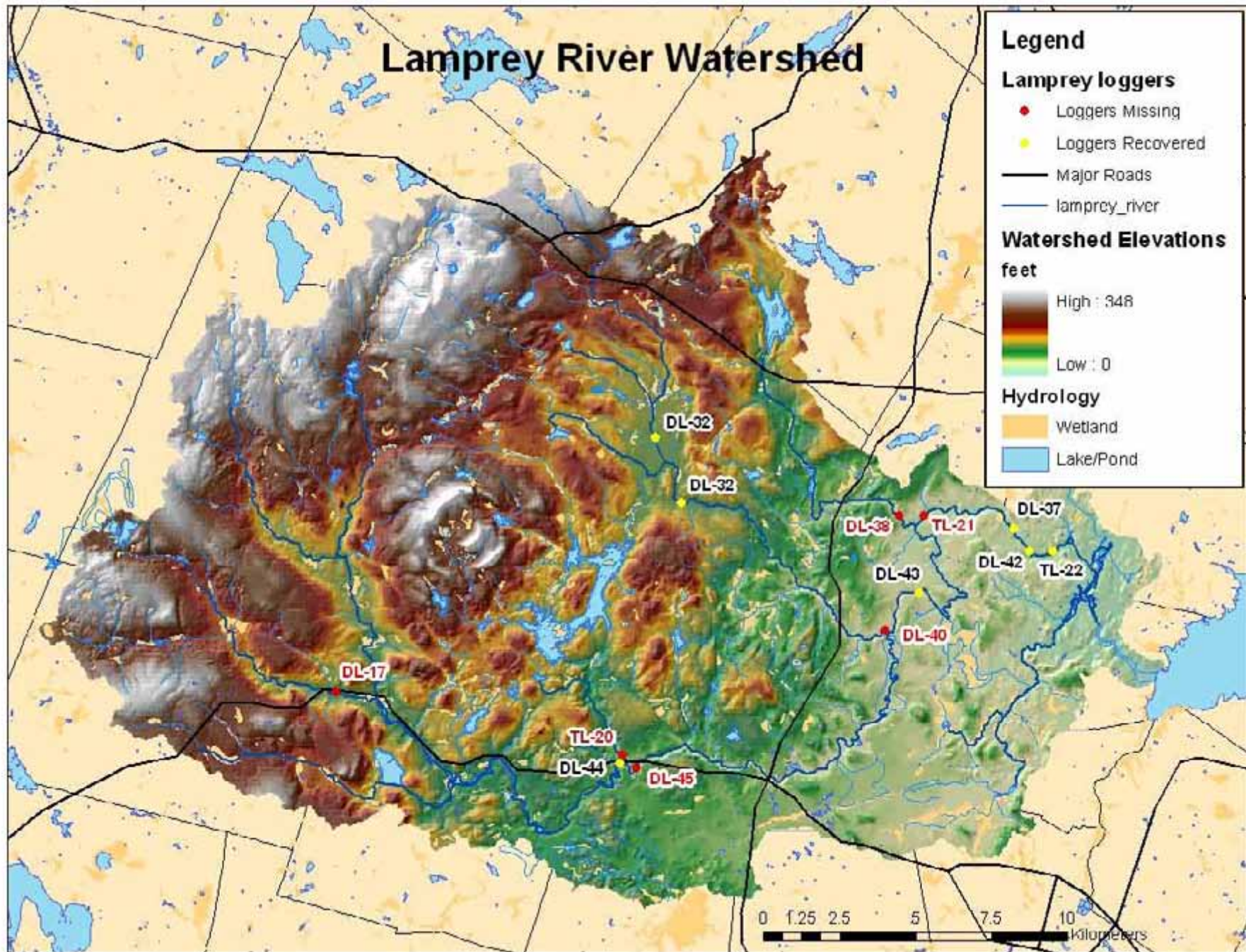
DL-17

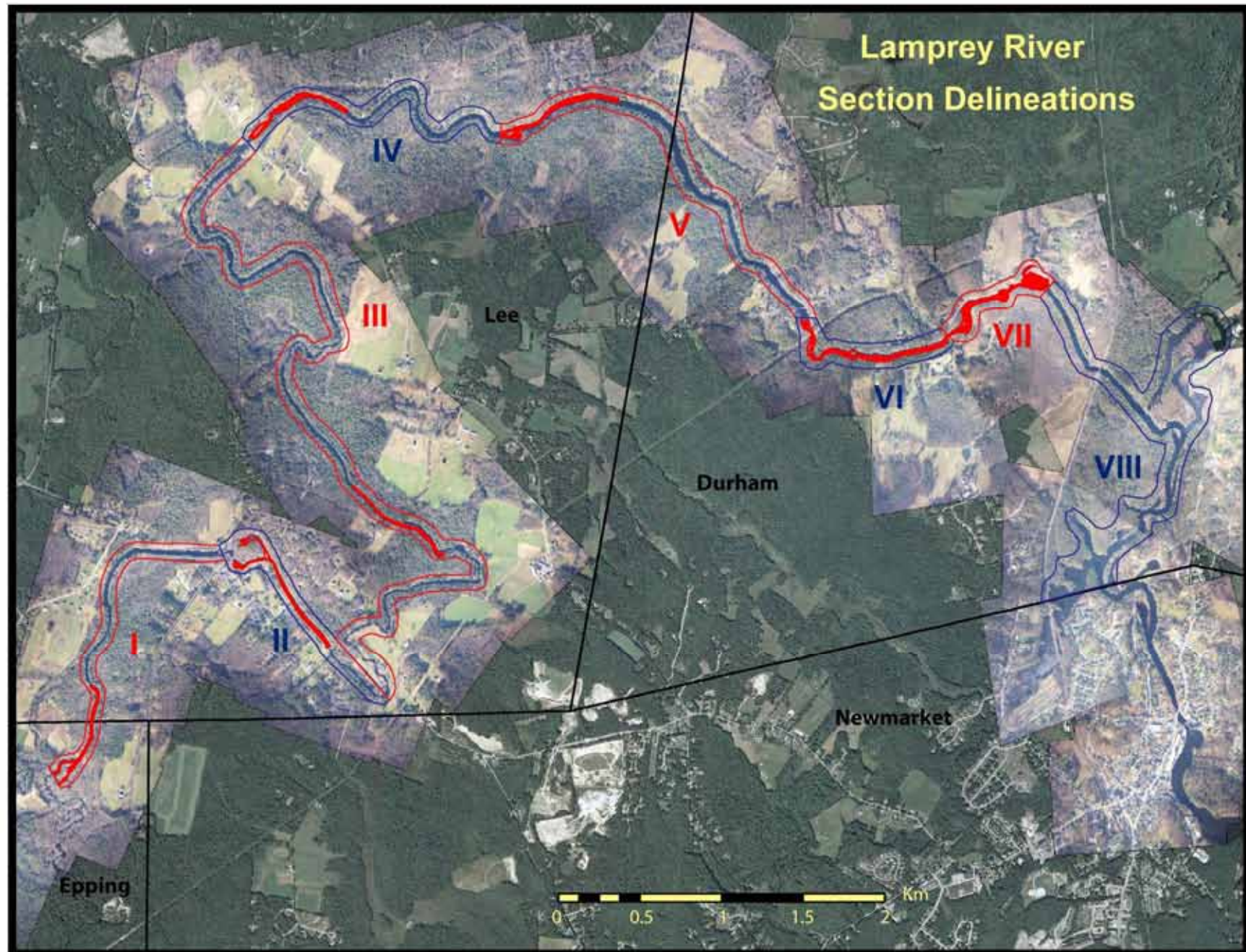
TL-20

DL-44

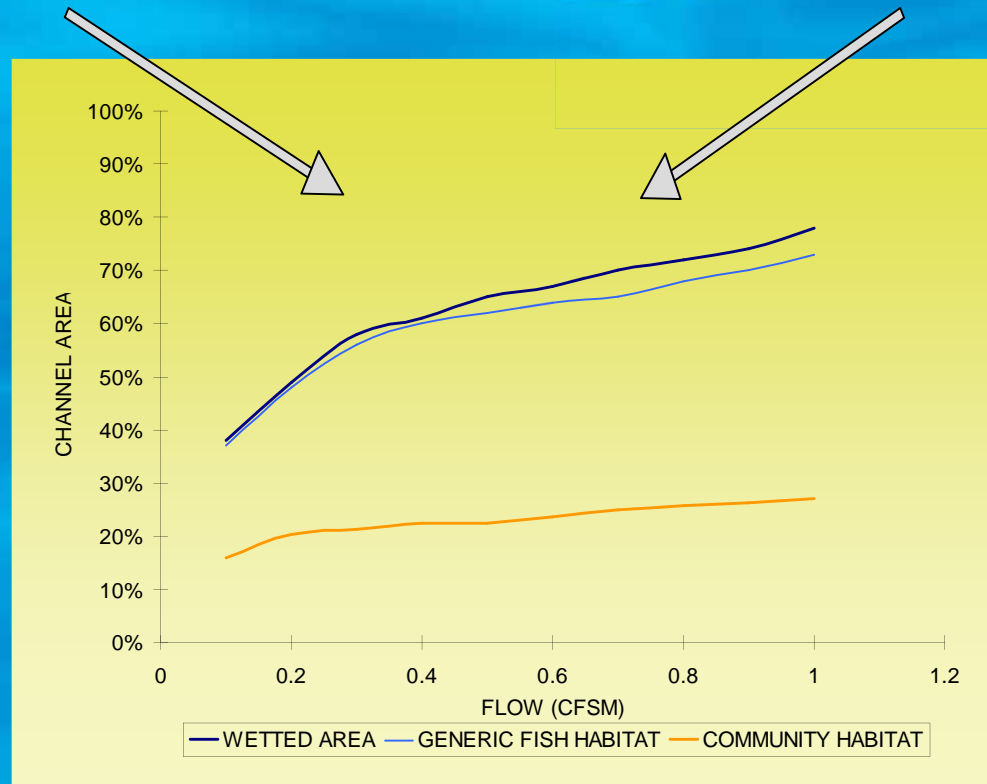
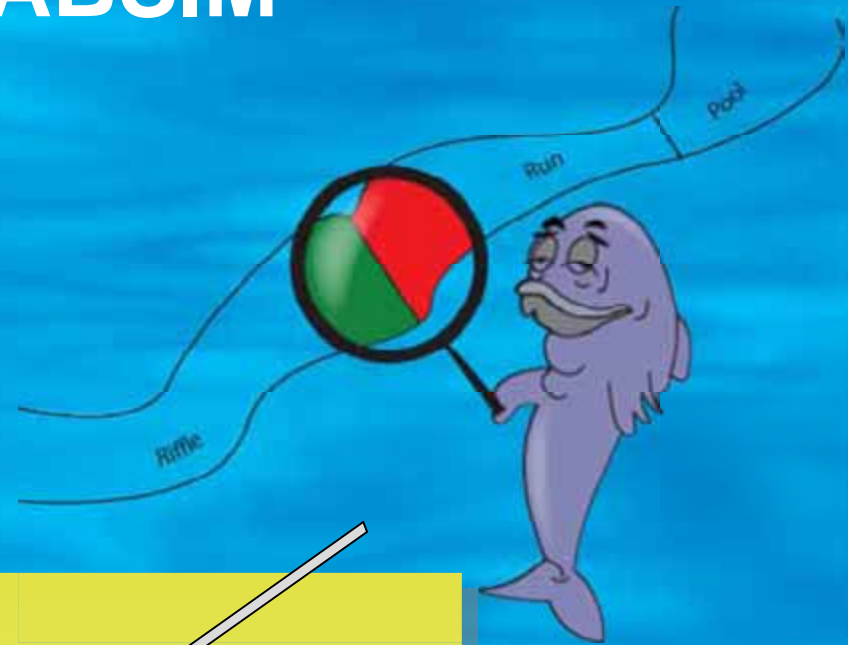
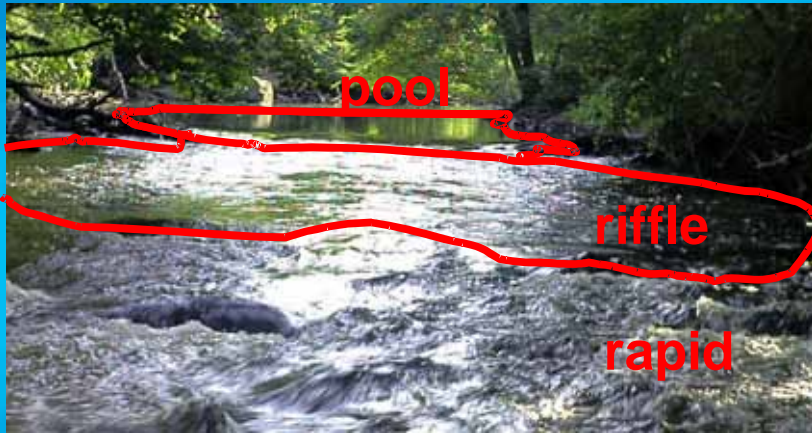
DL-45

0 1.25 2.5 5 7.5 10 kilometers





# MesoHABSIM



# MesoHABSIM Process

## 1. Biological targets and indicators

- a. Reference fauna
- b. Bioperiods
- c. Indicators

## 2. Biological filters

- a. Literature based criteria
- b. Empirical data

## 3. Instream Habitat classification

- a. Delineation
- b. Evaluation
- c. Upscaling

## 4. Adjusting biophysical template

- a. Identify habitat deficiencies
- b. Simulate habitat improvements

## 5. Time Series Analysis

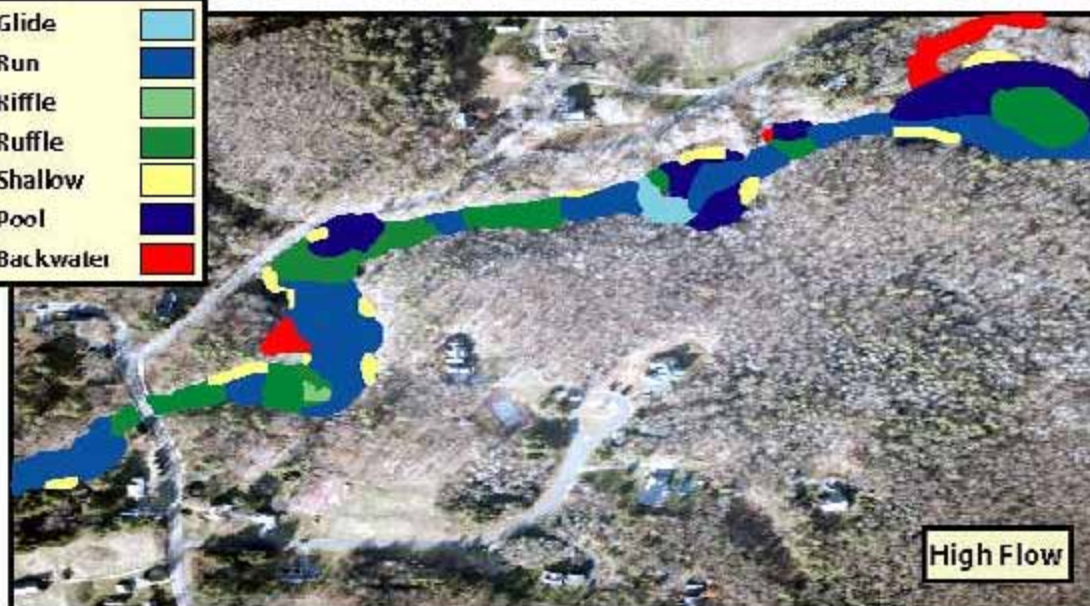
## 6. Interpretation and Application

- a. Restoration recommendations
- b. Flow management criteria

## Simulated Multispectral HMU Mapping of Lamprey River

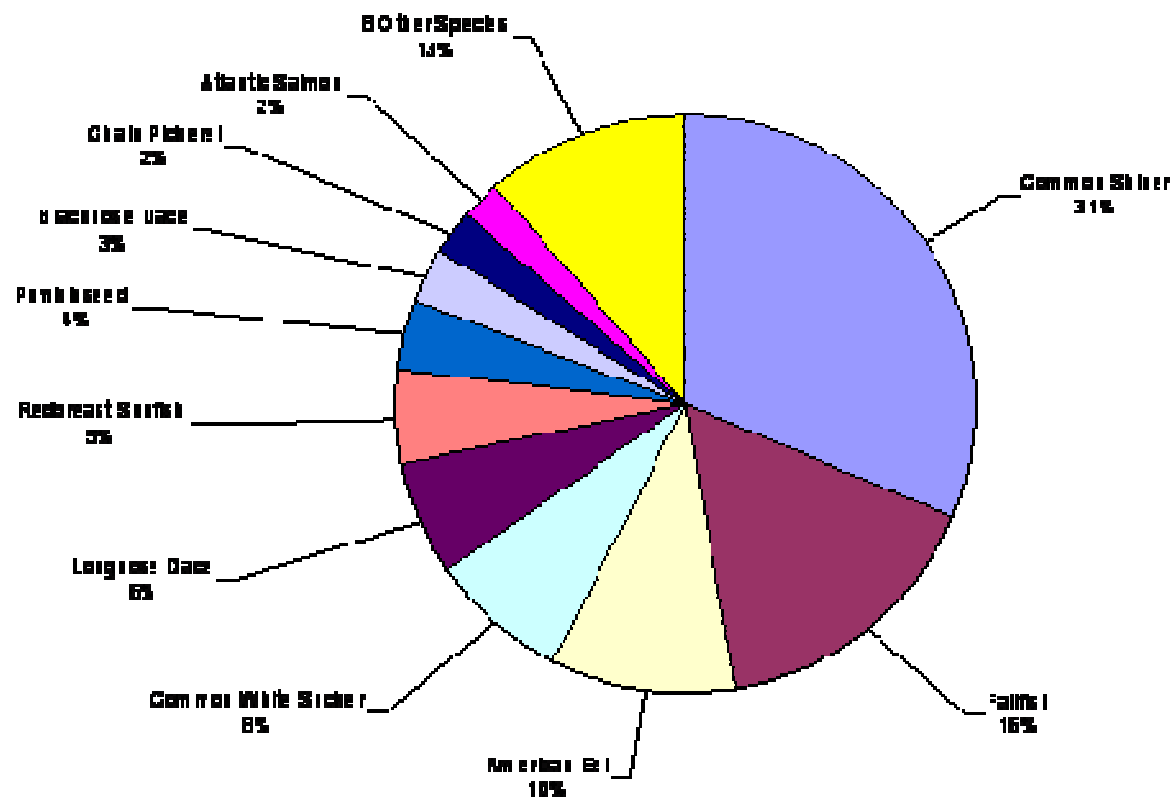


| HMU Legend |           |  |  |
|------------|-----------|--|--|
|            | Glide     |  |  |
|            | Run       |  |  |
|            | Riffle    |  |  |
|            | Ruffle    |  |  |
|            | Shallow   |  |  |
|            | Pool      |  |  |
|            | Backwater |  |  |

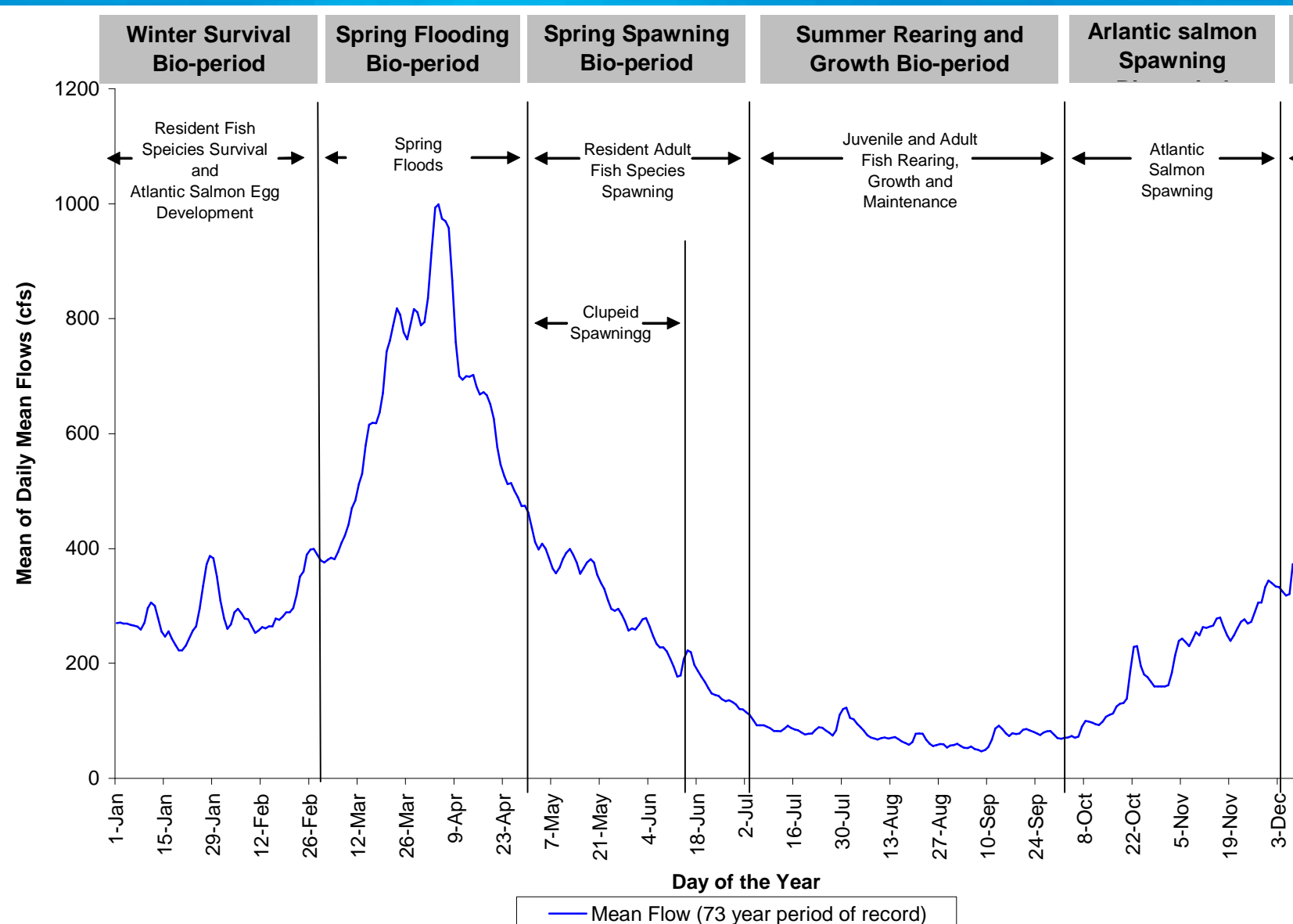


Example of proposed use of multispectral high-resolution imagery to remotely classify hydro-morphological units. Close-up area (lower left) shows Packers Falls region along Bennett road.

## Target Fish Community



# Bioperiods



# Species Selected for Habitat Modeling (summer)

Fallfish



Redbreast sunfish



Common shiner



Longnose dace



White sucker



Blacknose dace



Atlantic salmon



# Suitability Models

## Longnose dace

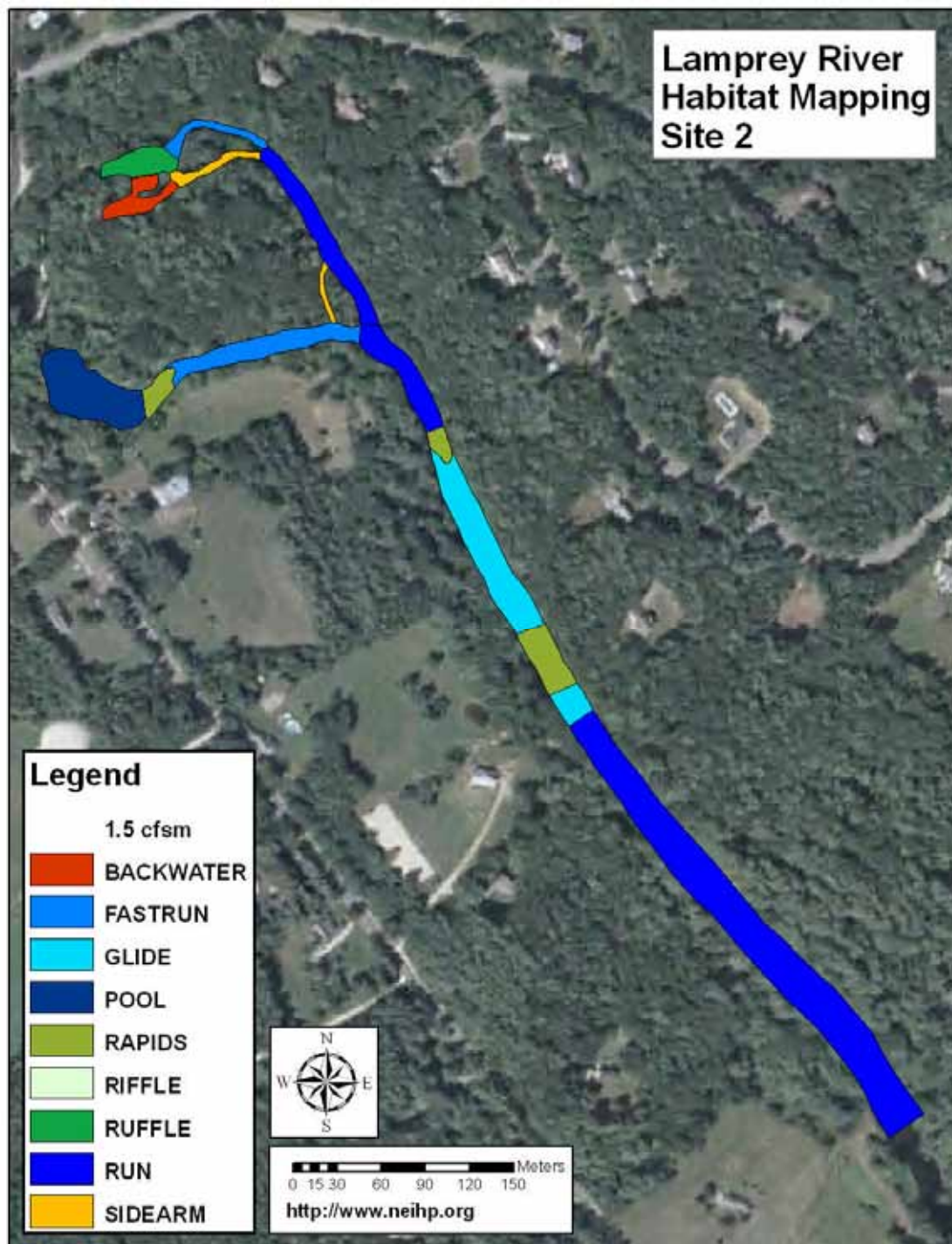
| Presence Model                |        | Abundance Model              |        |
|-------------------------------|--------|------------------------------|--------|
| Area Under ROC curve          | 0.86   | Area Under ROC curve         | 0.76   |
| Selected cut-off (PT)         | 0.1    | Selected cut-off (PT)        | 0.05   |
| Variables in the Equation     | b      | Variables in the Equation    | b      |
| Riprap                        | 0.828  | Riffle                       | 2.336  |
| Overhanging Vegetation        | -0.433 | Current Velocity 0 - 15 cm/s | 2.507  |
| Riffle                        | 2.342  | Constant                     | -2.192 |
| Ruffle                        | 1.667  |                              |        |
| Depth 0 - 25 cm               | 1.963  |                              |        |
| Current Velocity 0 - 15 cm/s  | 1.821  |                              |        |
| Current Velocity 15 - 30 cm/s | 1.435  |                              |        |
| Current Velocity 75 - 90 cm/s | 5.065  |                              |        |
| Akal                          | 3.32   |                              |        |
| Megalithal                    | 1.925  |                              |        |
| Constant                      | -6.273 |                              |        |

Watershed area = 183 mi<sup>2</sup>

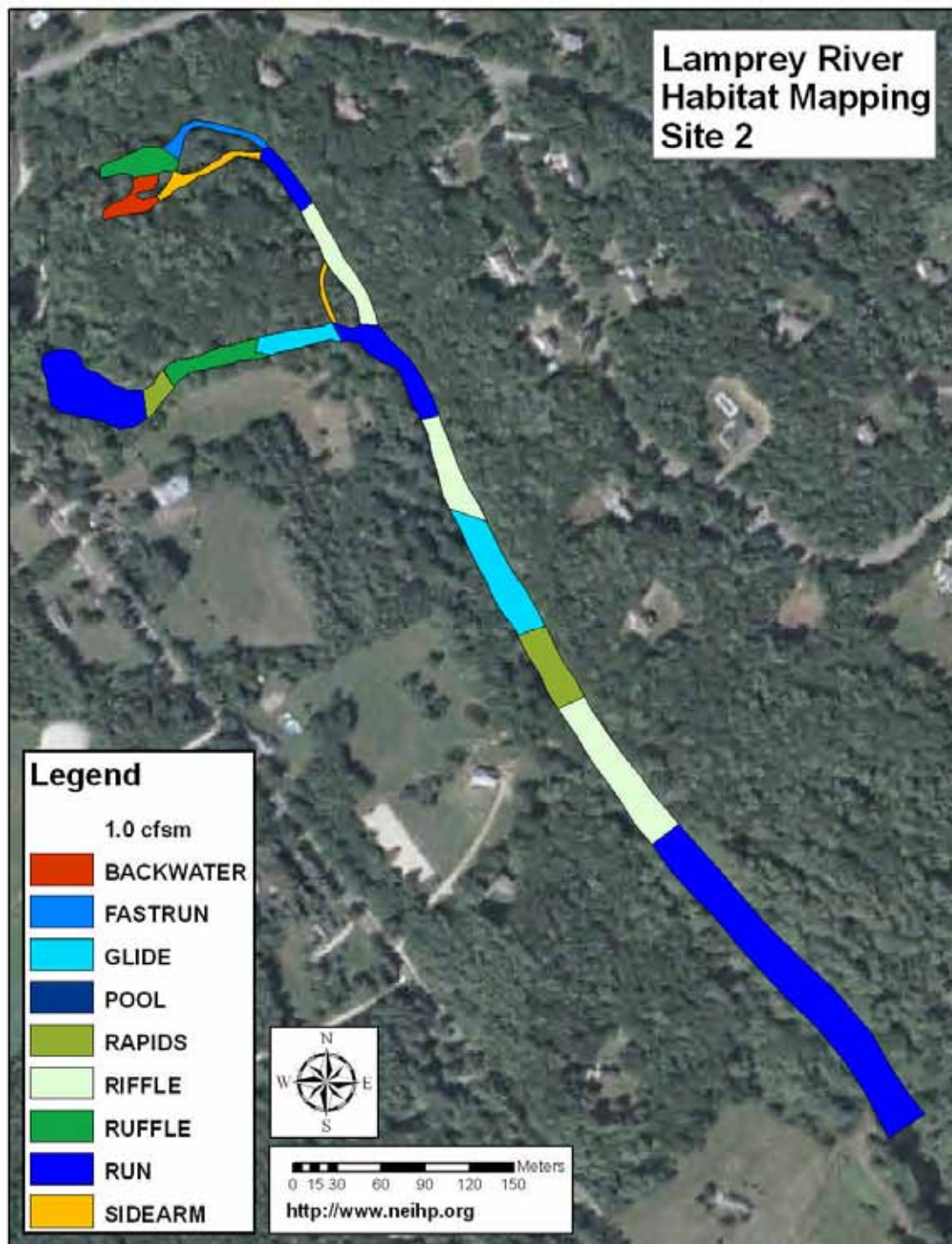
## Lamprey H MU Survey Chart

|        | ~18 0.1 cfs/m            |       |     |       |      | ~37 0.2 cfs/m                                                                                                                                                                                                               |       |     |       |      |
|--------|--------------------------|-------|-----|-------|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-----|-------|------|
|        | Date                     | cfs/m | cfs | start | stop | Date                                                                                                                                                                                                                        | cfs/m | cfs | start | stop |
| Site 1 | 8/21/2007                | 0.09  | 16  | 16    | 16   | 9/19/2006                                                                                                                                                                                                                   | 0.26  | 47  | 47    | 47   |
| Site 2 | 8/21/2007                | 0.09  | 16  | 16    | 16   | 9/19/2006                                                                                                                                                                                                                   | 0.25  | 47  | 47    | 46   |
| Site 3 | 8/21/2007                | 0.09  | 16  | 16    | 16   | 9/19/2006                                                                                                                                                                                                                   | 0.25  | 45  | 45    | 45   |
| Site 4 | 8/22/2007                | 0.08  | 15  | 15    | 15   | 9/19/2006                                                                                                                                                                                                                   | 0.25  | 45  | 45    | 45   |
| Site 5 | 8/22/2007                | 0.08  | 14  | 14    | 14   | 9/28/2006                                                                                                                                                                                                                   | 0.28  | 52  | 52    | 52   |
| Site 6 | 8/22/2007                | 0.08  | 14  | 14    | 14   | 9/28/2006                                                                                                                                                                                                                   | 0.28  | 52  | 52    | 51   |
| Site 7 | 8/23/2007                | 0.08  | 14  | 14    | 14   | 9/28/2006                                                                                                                                                                                                                   | 0.27  | 50  | 51    | 49   |
|        | ~90 0.5 cfs/m            |       |     |       |      | ~183 1.0 cfs/m                                                                                                                                                                                                              |       |     |       |      |
|        | Date                     | cfs/m | cfs | start | stop | Date                                                                                                                                                                                                                        | cfs/m | cfs | start | stop |
| Site 1 | 7/20/2006                | 0.56  | 103 | 104   | 102  | 4/28/2006                                                                                                                                                                                                                   | 0.95  | 173 | 174   | 172  |
| Site 2 | 7/20/2006                | 0.55  | 101 | 102   | 100  | 4/27/2006                                                                                                                                                                                                                   | 1.28  | 235 | 241   | 229  |
| Site 3 | 7/20/2006                | 0.53  | 98  | 98    | 97   | 4/27/2006                                                                                                                                                                                                                   | 1.24  | 227 | 227   | 227  |
| Site 4 | 7/20/2006                | 0.53  | 97  | 97    | 97   | 4/27/2006                                                                                                                                                                                                                   | 1.22  | 223 | 225   | 220  |
| Site 5 | 7/20/2006                | 0.52  | 95  | 95    | 95   | 4/27/2006                                                                                                                                                                                                                   | 1.19  | 217 | 218   | 216  |
| Site 6 | 7/21/2006                | 0.48  | 88  | 89    | 87   | 4/28/2006                                                                                                                                                                                                                   | 1.00  | 183 | 188   | 178  |
| Site 7 | 7/21/2006                | 0.48  | 87  | 87    | 87   | 4/28/2006                                                                                                                                                                                                                   | 0.96  | 176 | 176   | 176  |
|        | ~275 -360 1.5 -2.0 cfs/m |       |     |       |      | <p>Start/stop refers to the cfs at the Newmarket gauge at the start and finish of each mapping of a representative site. The cfs at the time of mapping was then calculated by taking the average of these two numbers.</p> |       |     |       |      |
|        | Date                     | cfs/m | cfs | start | stop |                                                                                                                                                                                                                             |       |     |       |      |
| Site 1 | 7/25/2006                | 2.00  | 366 | 370   | 362  |                                                                                                                                                                                                                             |       |     |       |      |
| Site 2 | 7/25/2006                | 1.89  | 345 | 354   | 336  |                                                                                                                                                                                                                             |       |     |       |      |
| Site 3 | 7/25/2006                | 1.81  | 331 | 333   | 328  |                                                                                                                                                                                                                             |       |     |       |      |
| Site 4 | 7/26/2006                | 1.47  | 269 | 271   | 266  |                                                                                                                                                                                                                             |       |     |       |      |
| Site 5 | 7/26/2006                | 1.42  | 261 | 262   | 259  |                                                                                                                                                                                                                             |       |     |       |      |
| Site 6 | 7/26/2006                | 1.37  | 251 | 257   | 245  |                                                                                                                                                                                                                             |       |     |       |      |
| Site 7 | 7/26/2006                | 1.30  | 239 | 241   | 236  |                                                                                                                                                                                                                             |       |     |       |      |

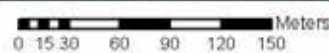
Lamprey River  
Habitat Mapping  
Site 2



Lamprey River  
Habitat Mapping  
Site 2

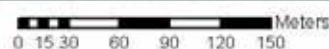


Lamprey River  
Habitat Mapping  
Site 2



<http://www.neihp.org>

Lamprey River  
Habitat Mapping  
Site 2



<http://www.neihp.org>

## Wiswall Dam Impoundment

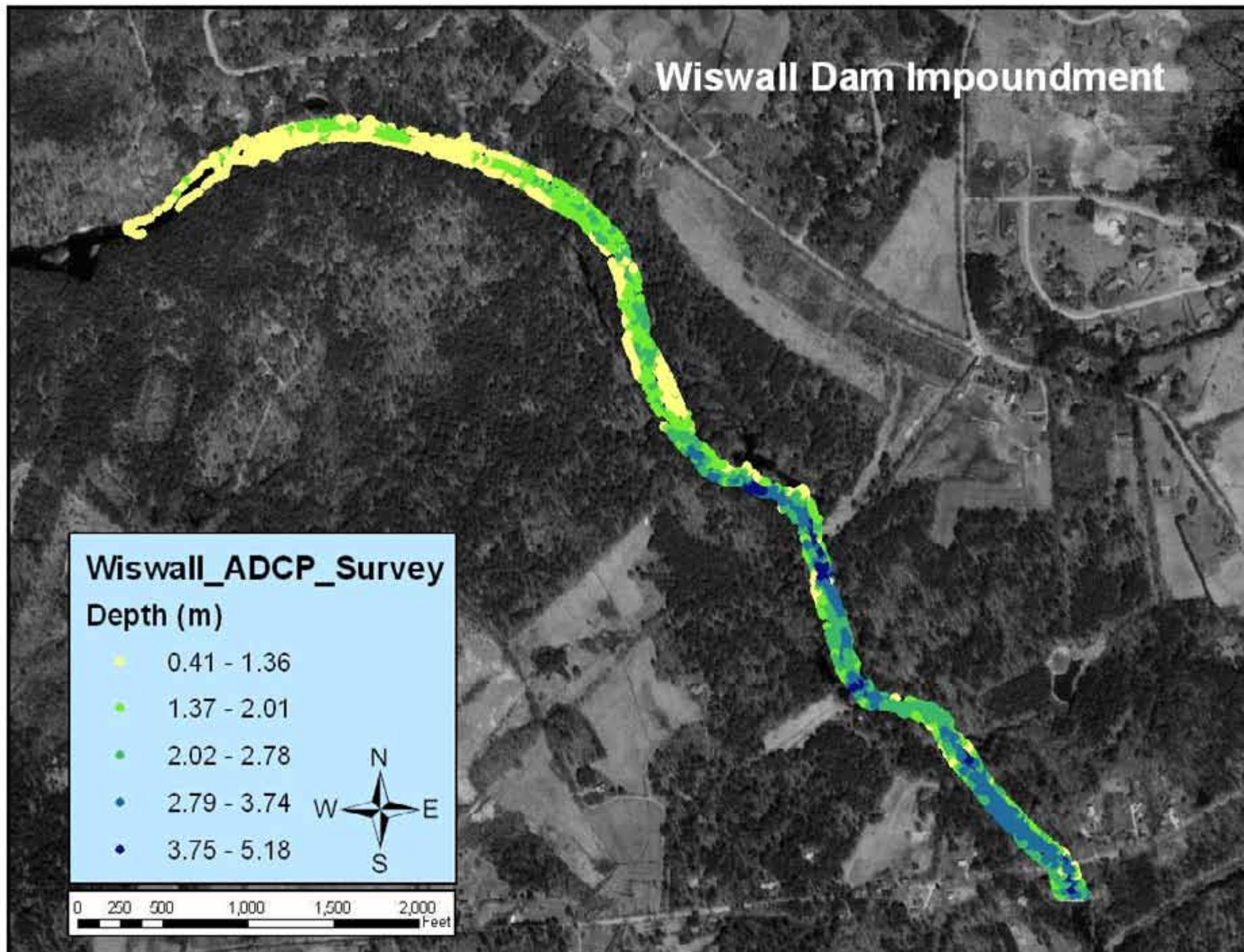
### Wiswall\_ADCP\_Survey

Depth (m)

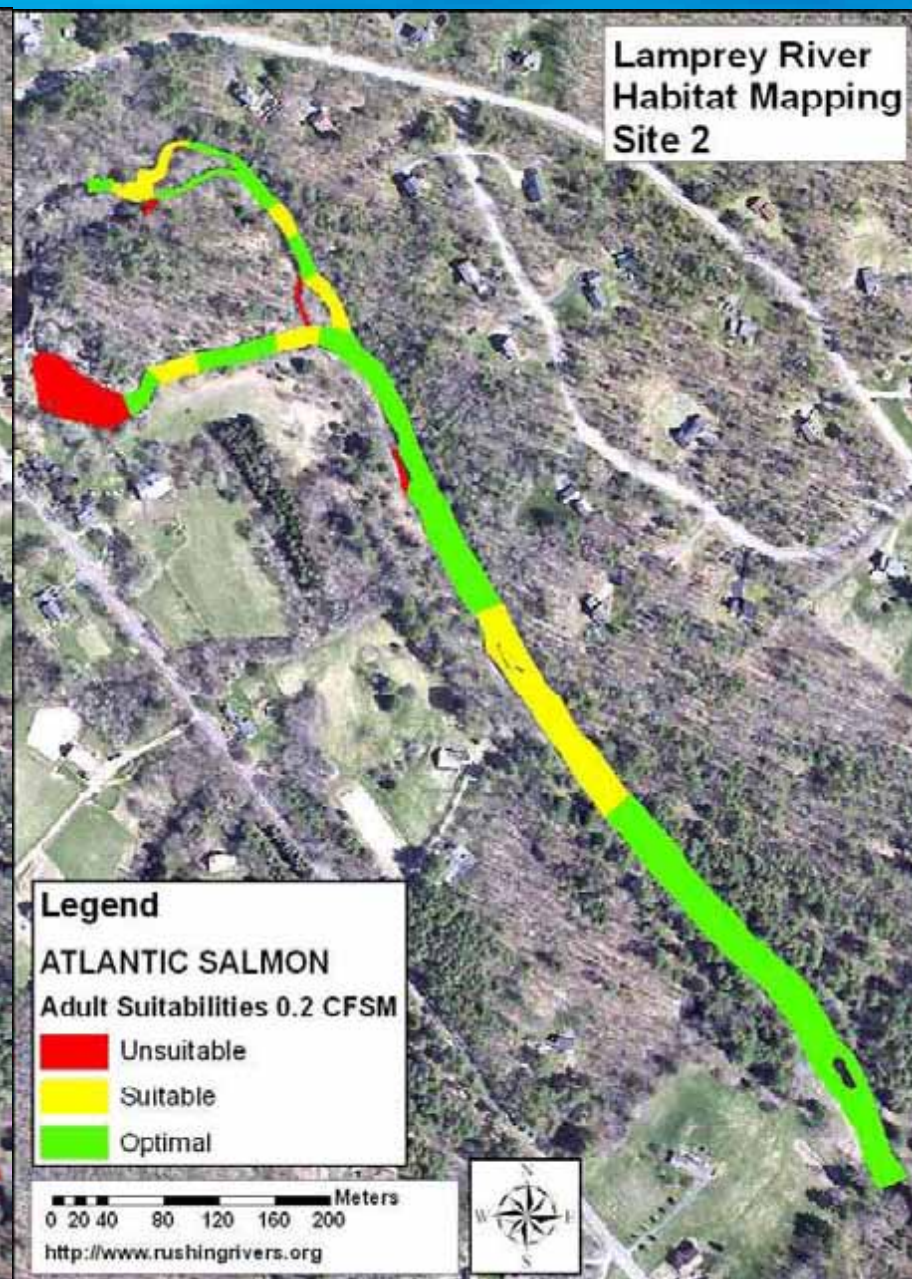
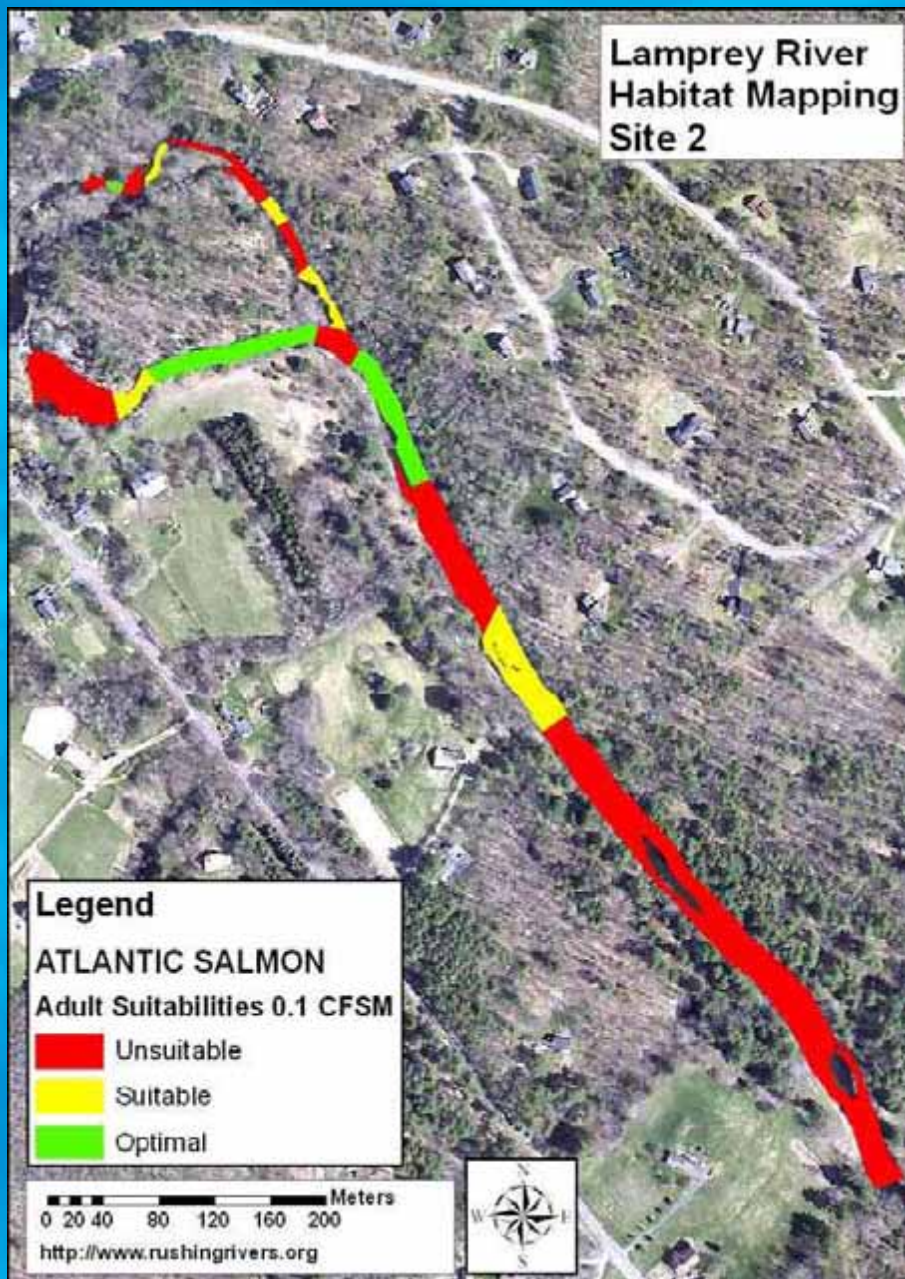
- 0.41 - 1.36
- 1.37 - 2.01
- 2.02 - 2.78
- 2.79 - 3.74
- 3.75 - 5.18



0 250 500 1,000 1,500 2,000  
feet



# Habitat Maps

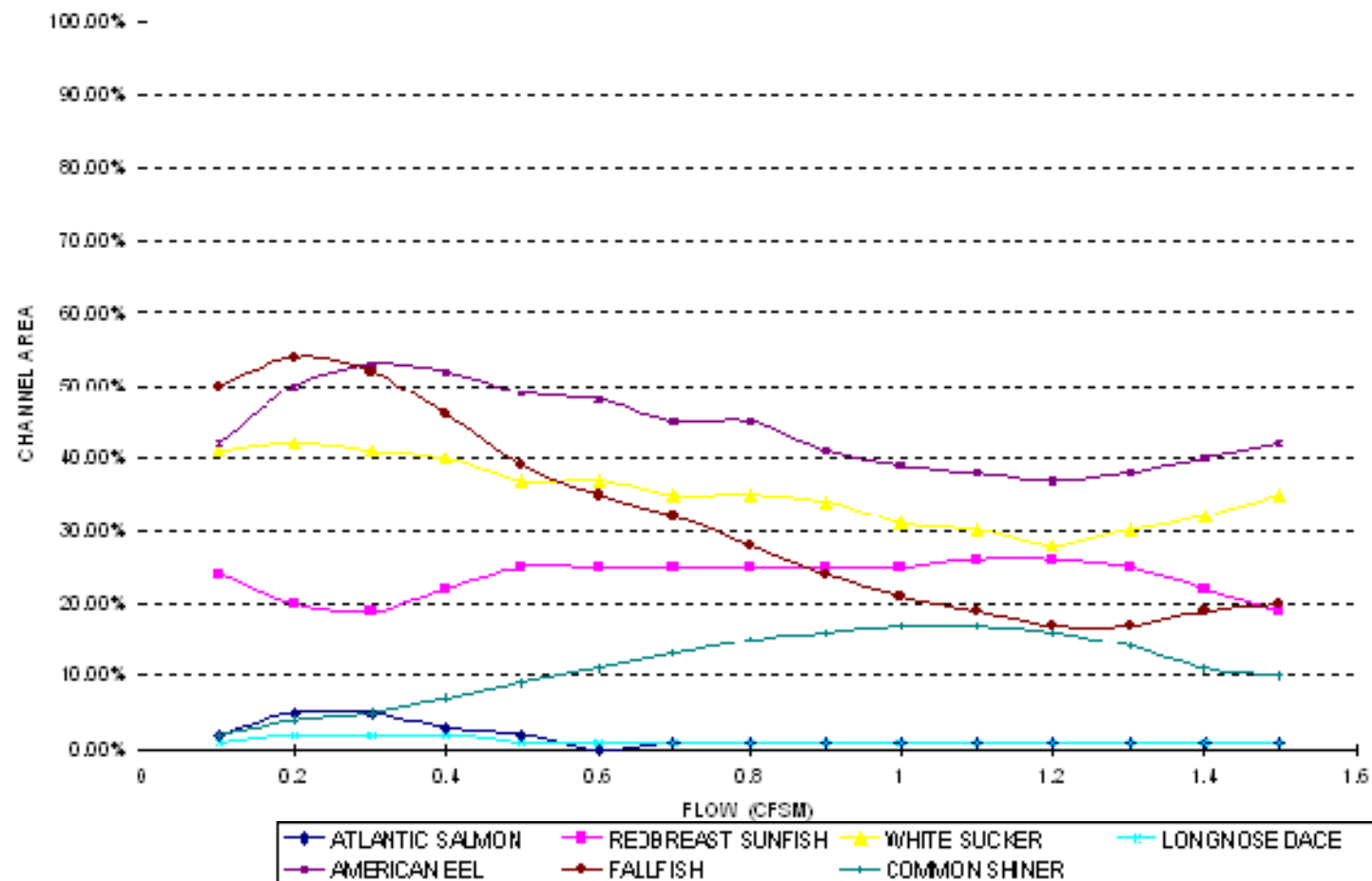


# Suitable Habitat for Fish



Suitability Curve(s) for Whole Project

Project: Lamprey River AIC  
Curve: Suitability



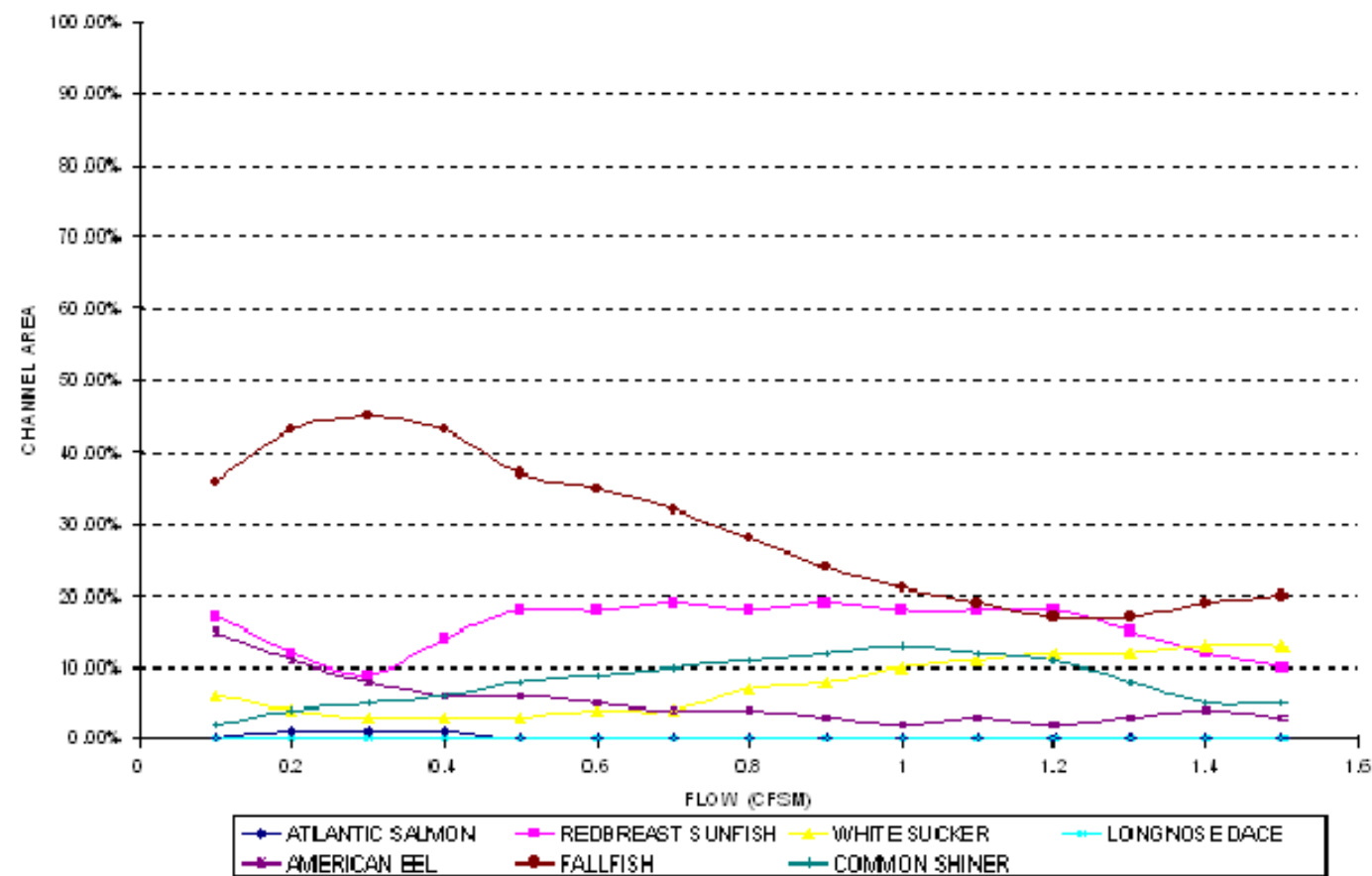
# Optimal Habitat for Fish



Suitability Curve(s) for Whole Project

Project: Lamprey River AIC

Curve: Optimal

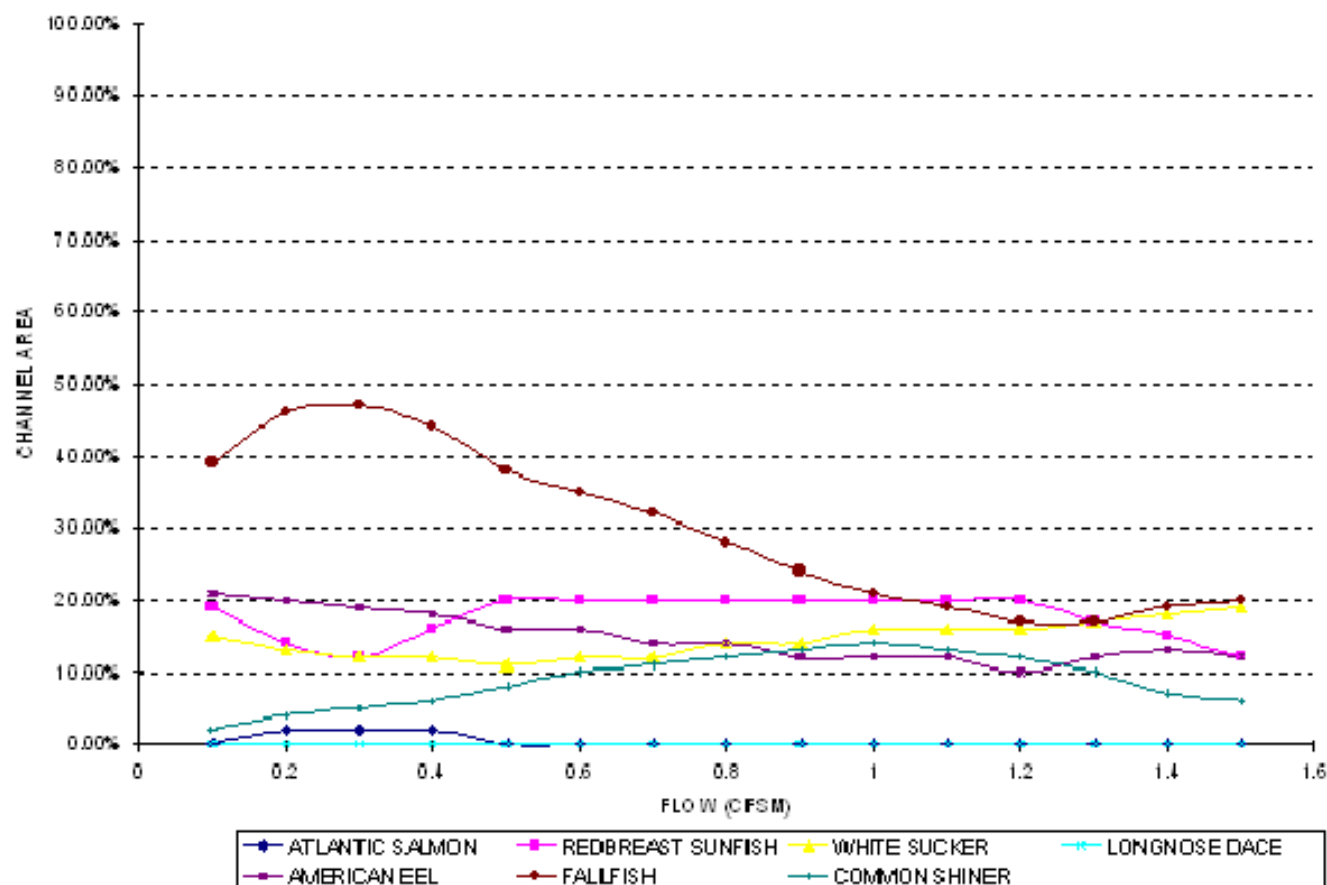


# Effective Habitat for Fish



Suitability Curve(s) for Whole Project

Project: Lamprey River AIC  
Effective Habitat

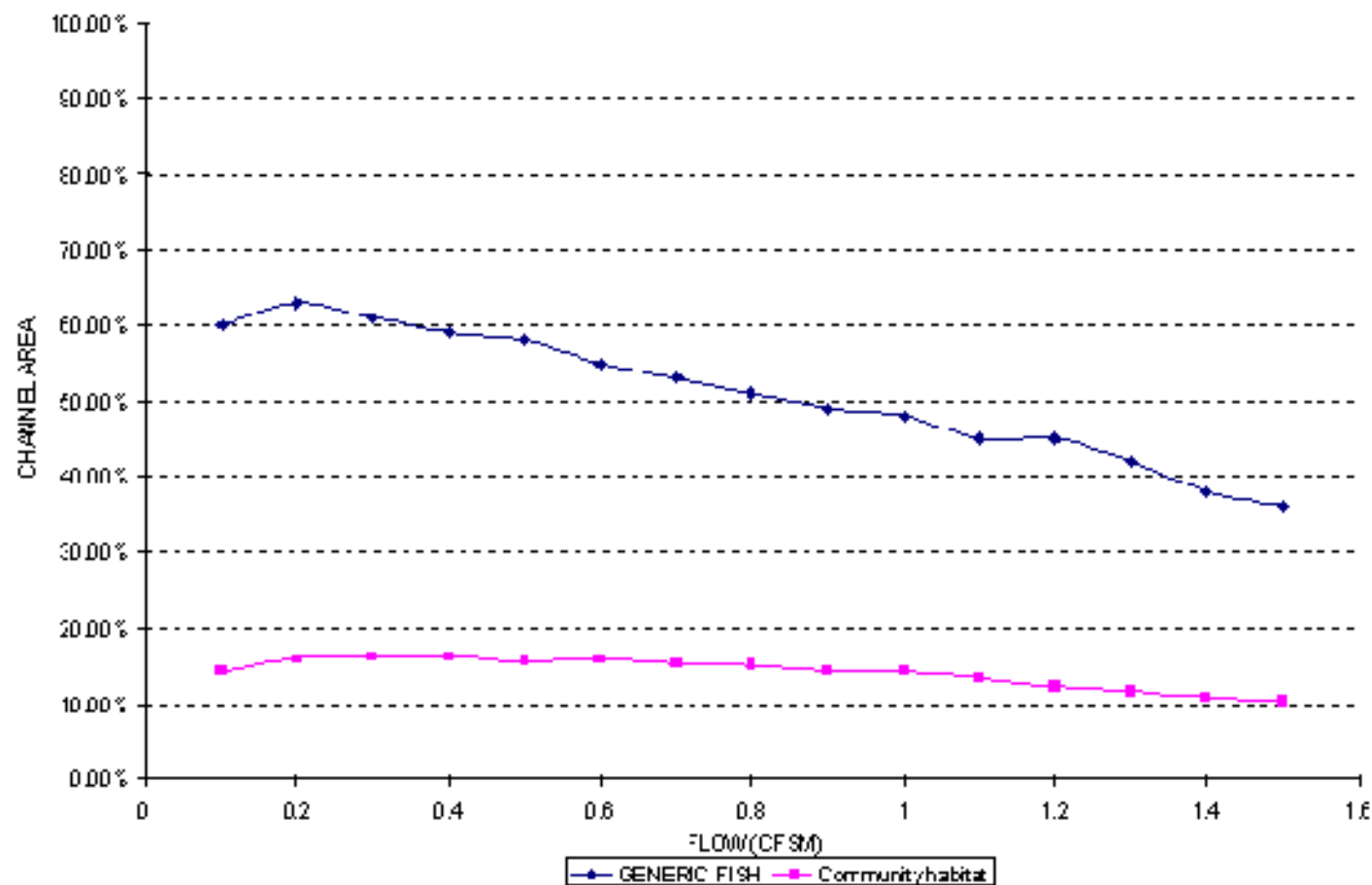


# Effective Habitat for Fish Community



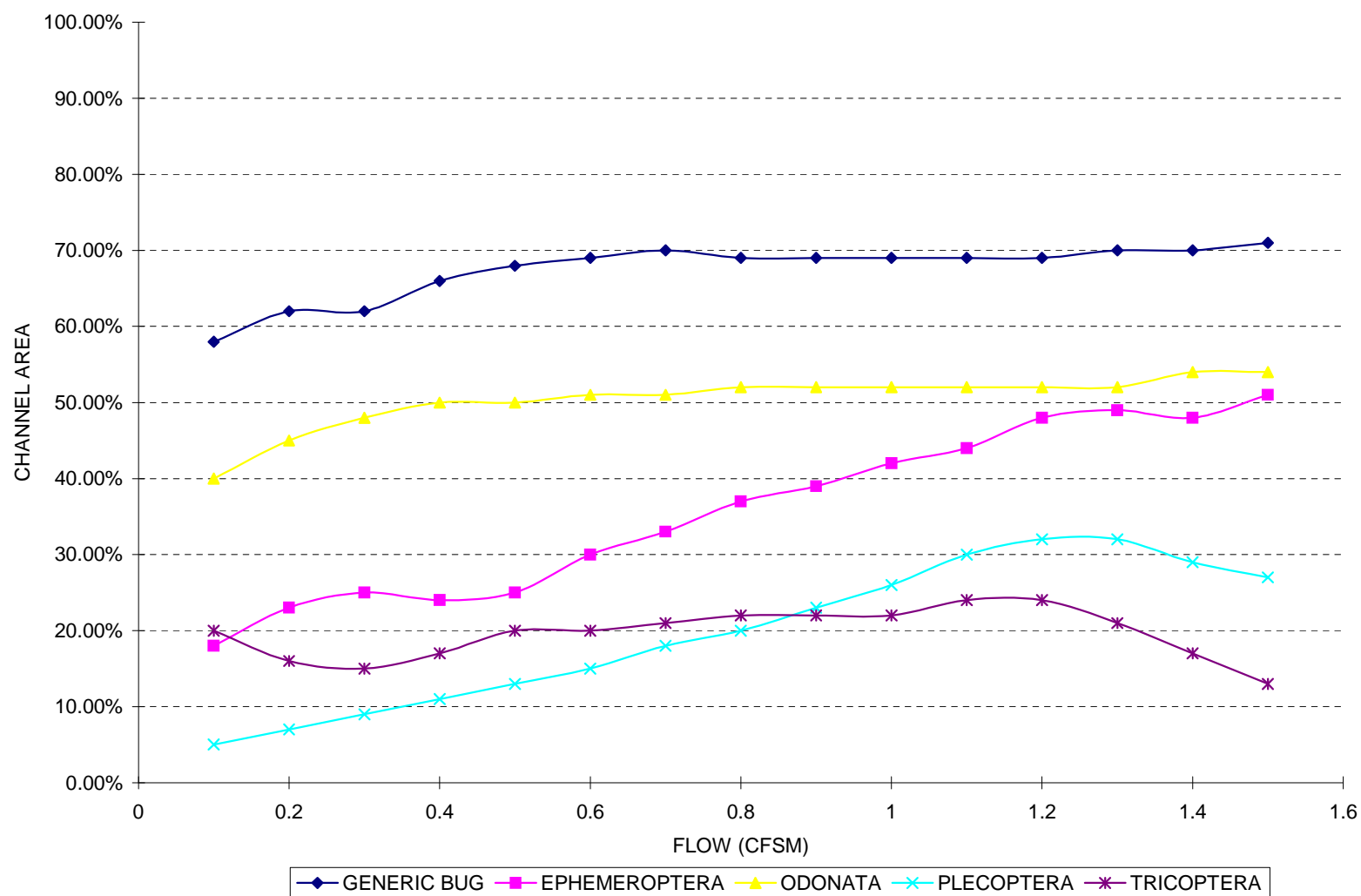
Community Habitat Suitability Curve for Whole Project

Project: Lamprey River AIC  
Effective Habitat

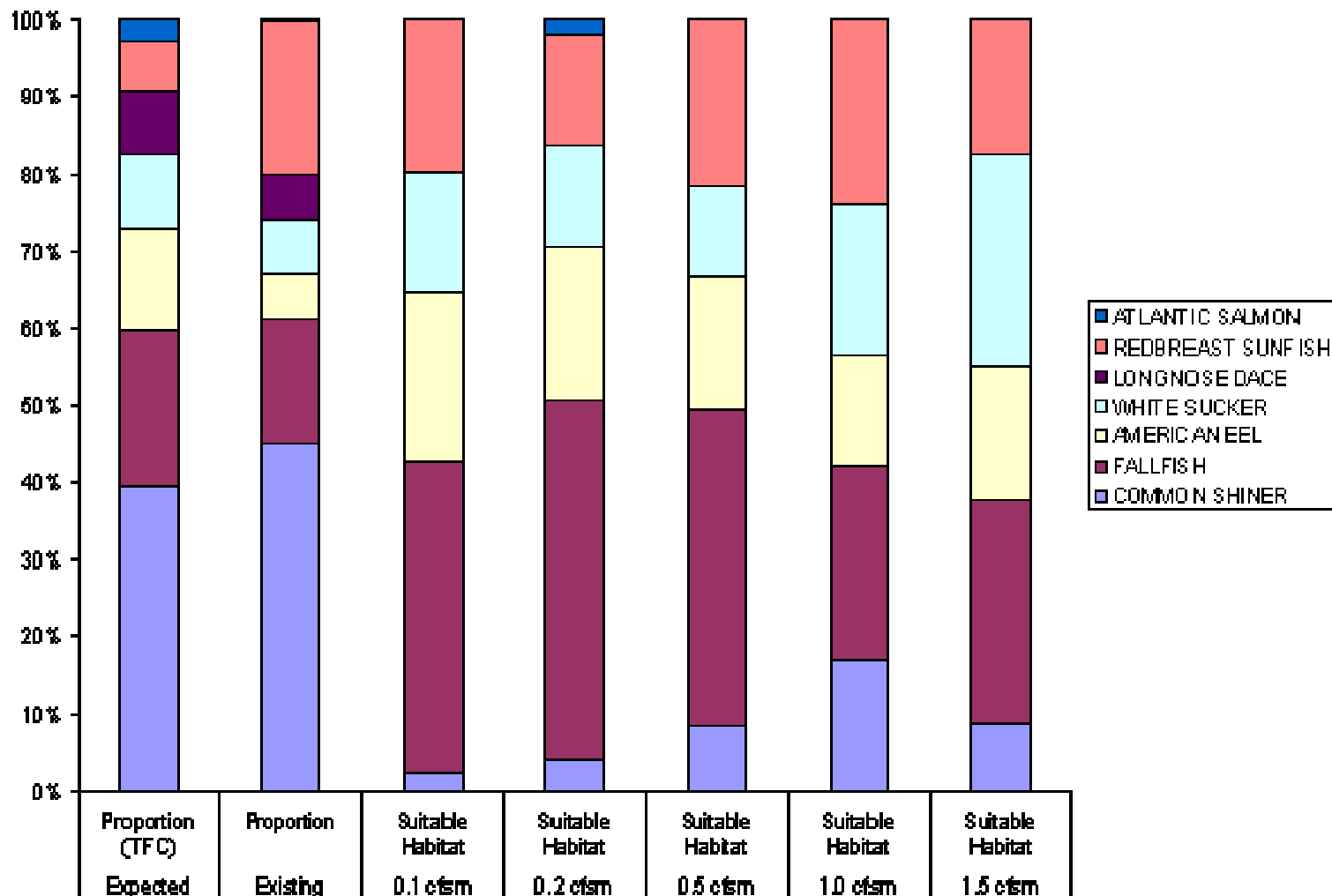


## Suitability Curve(s) for Whole Project

**Project: Lamprey River Bugs AIC**  
Effective Habitat



# Habitat vs. Fish Community



# Effective Habitat for Fish Restored

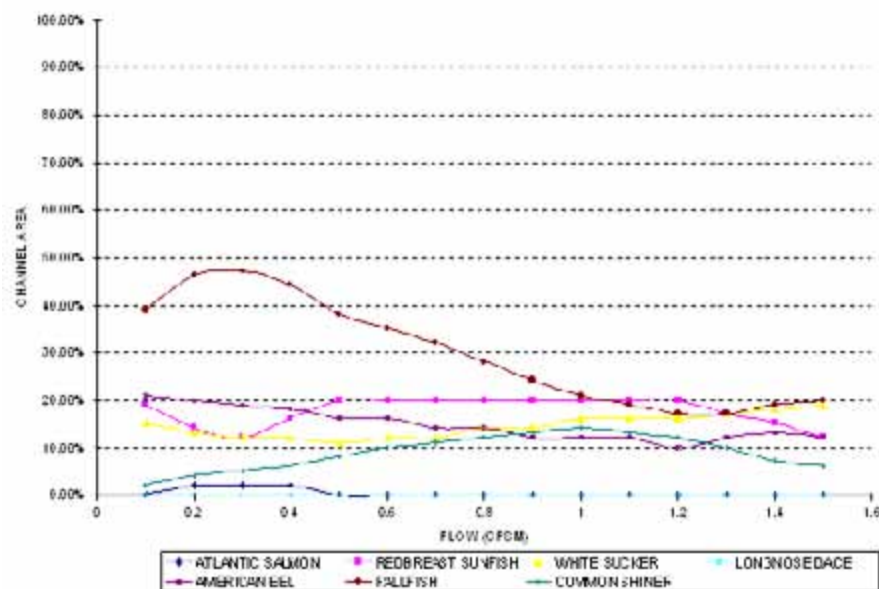
## Current

## Baseline



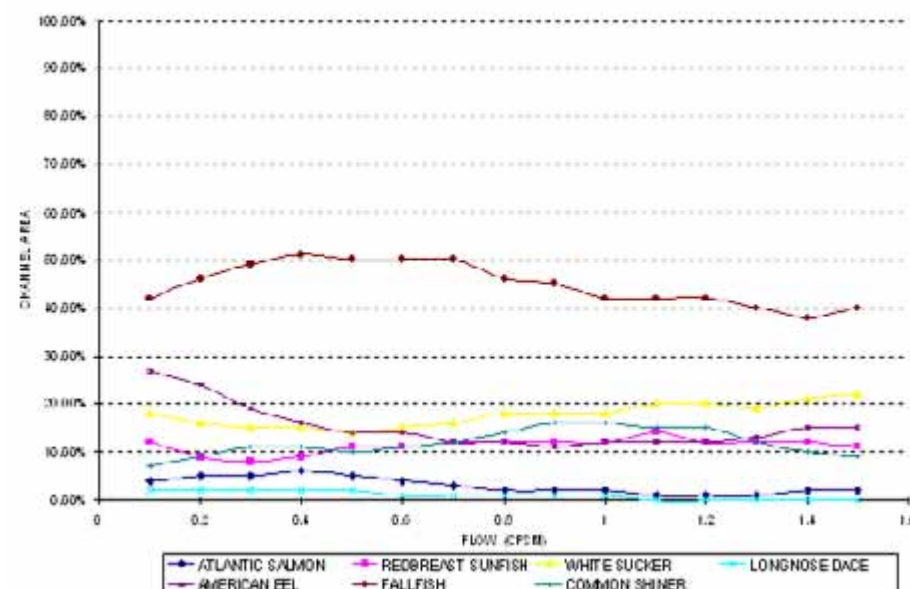
Suitability Curve(s) for Whole Project

Project: Lamprey River AIC  
Effective Habitat



Suitability Curve(s) for Whole Project

Project: Lamprey River AIC  
Effective Habitat



# Effective Habitat for Fish Community

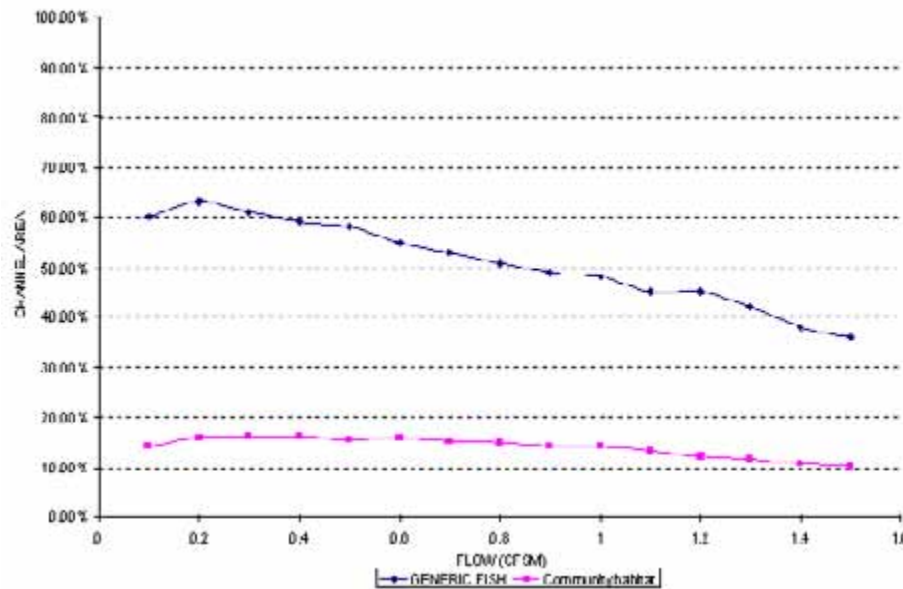
## Current

## Baseline



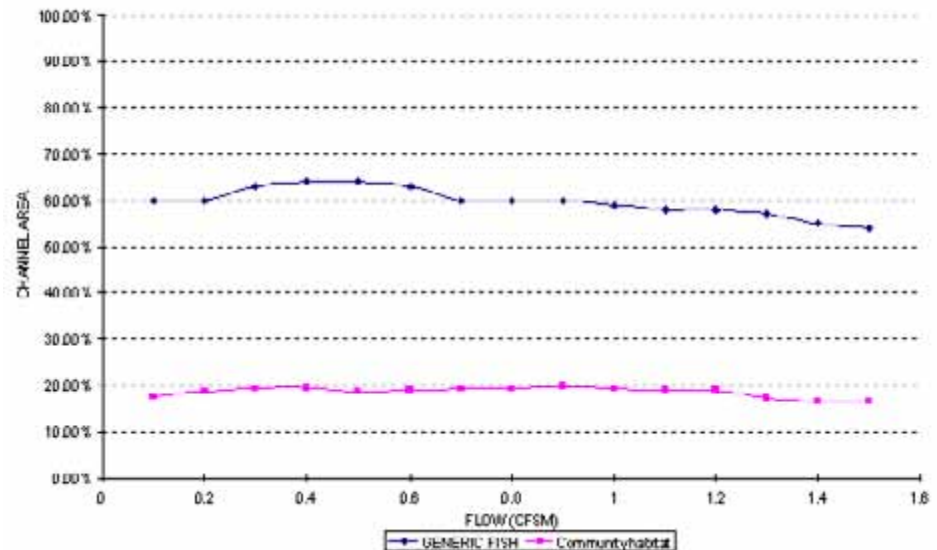
Community Habitat Suitability Curve for Whole Project

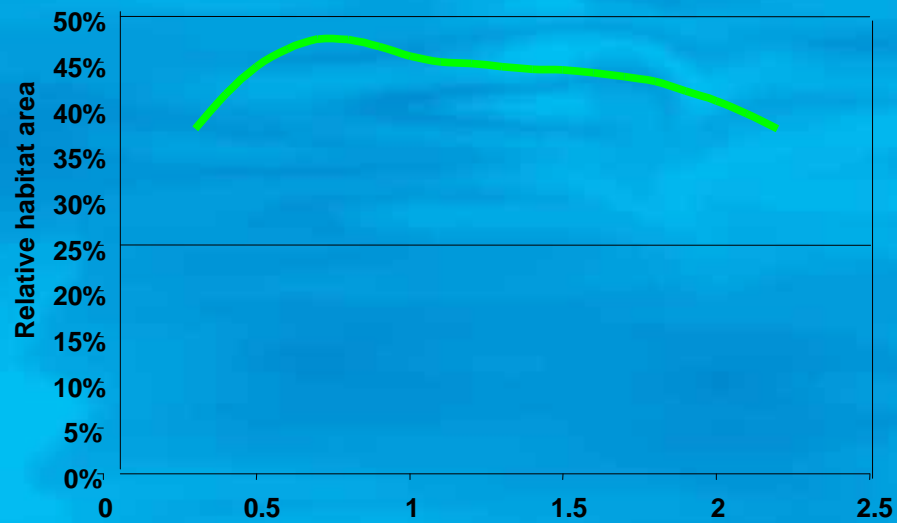
Project: Lamprey River AIC  
Effective Habitat



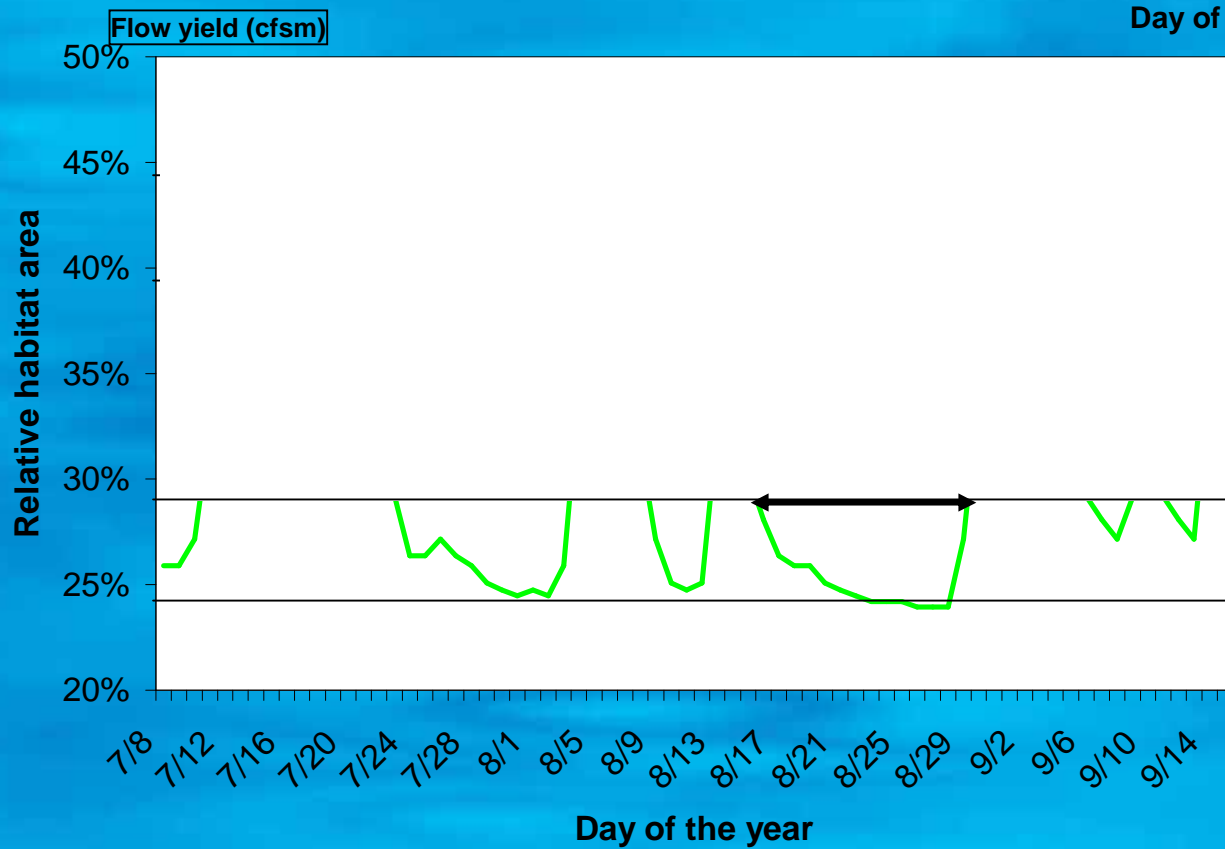
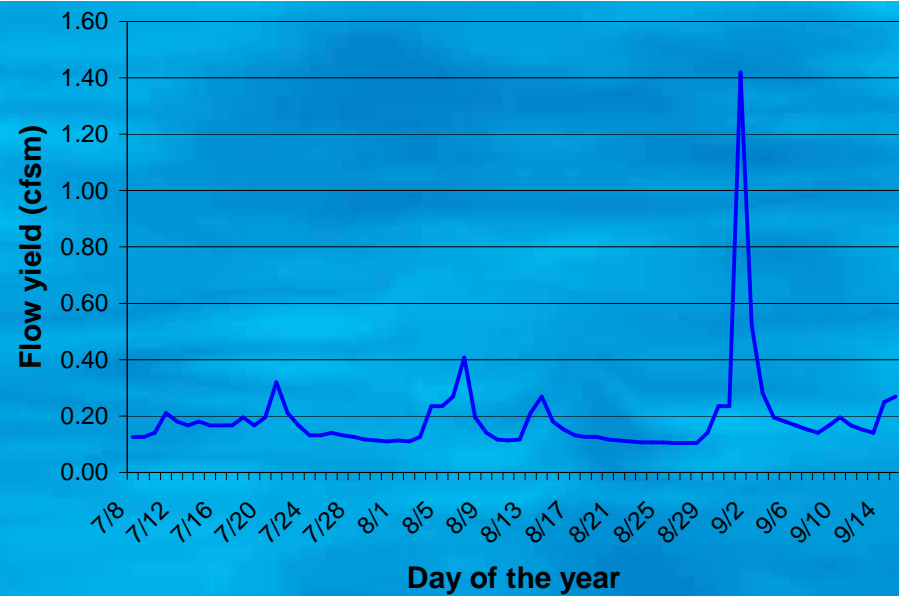
Community Species Suitability Curve for Whole Project

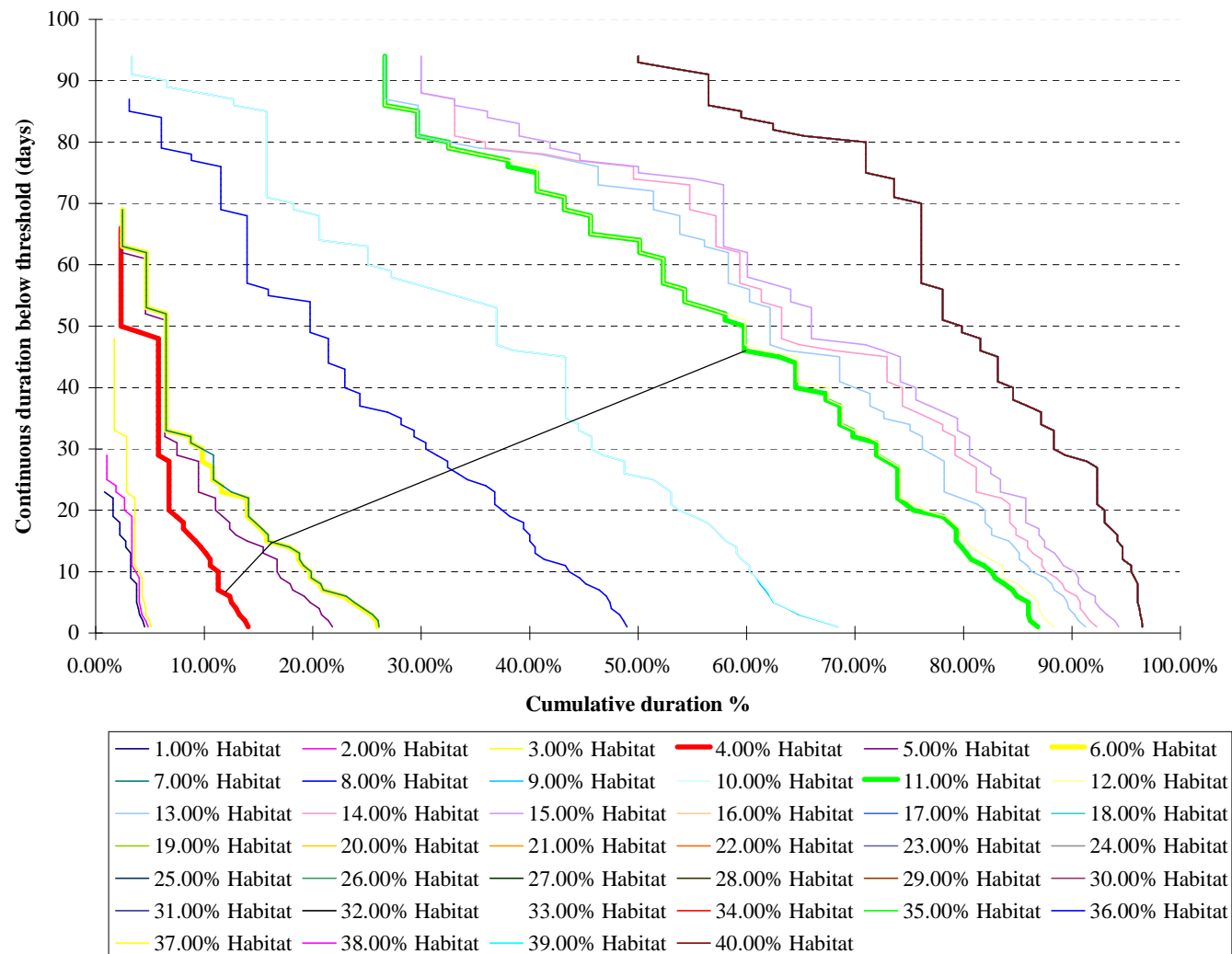
Project: Lamprey River AIC  
Effective Habitat





+





# Flow Thresholds

## The common flow:

- corresponding to the highest habitat magnitude above which the frequency of occurrence begins to decline significantly with incremental increase in habitat magnitude.
- near optimal habitat availability conditions.
- exceeded approximately 45% of the bioperiod.

# Flow Thresholds

## The critical flow:

- corresponding to the second to the lowest habitat magnitude for which the frequency of occurrence increases significantly with incremental increase in habitat magnitude.
- less habitat availability than that provided by the common flow, but this habitat magnitude is not unusual.
- exceeded approximately 65% to 85% of the bioperiod.

# Flow Thresholds

## The rare flow:

- corresponding to the lowest of habitat magnitudes for which the frequency of occurrence increases significantly with incremental increase in habitat magnitude.
- habitat availability is severely reduced and very uncommon.
- exceeded more than 90% of the bioperiod.

# Flow Duration Threshold

- **Allowable** – consecutive days with flow below protected magnitude for ordinary conditions – no flow management.
- **Catastrophic** - consecutive days with flow below protected magnitude for unacceptable conditions – trigger management.
- **Peristent** – longer then allowable, but shorter then catastrophic - trigger management after 3<sup>rd</sup> consecutive year.

# Fish PISF

| Bioperiod                         | Rearing & Growth | Salmon Spawning | Overwintering     | Spring Flood    |
|-----------------------------------|------------------|-----------------|-------------------|-----------------|
| Approximate dates                 | July 5 - Oct. 6  | Oct. 7 - Dec. 8 | Dec 9 - Feb. 28   | March 1 - May 4 |
| Indicator                         | Common shiner    | Atlantic Salmon | Flow              | Flow            |
| Watershed area (mi <sup>2</sup> ) | 183              | 183             | 183               | 183             |
| Common flow (cfs)                 | 110              | 90              | 237.9             | 622             |
| Common flow (cfsm)                | 0.60             | 0.49            | 1.30              | 3.40            |
| Allowable duration under (days)   | 46               | 17              | 20                | 14              |
| Catastrophic duration (days)      | 81               | 55              | 57                | 42              |
| Critical flow (cfs)               | 22               | 40              | 109.8             | 238             |
| Critical flow (cfsm)              | 0.12             | 0.22            | 0.60              | 1.30            |
| Allowable duration under (days)   | 15               | 11              | 10                | 10              |
| Catastrophic duration (days)      | 32               | 33              | 37                | 19              |
| Rare flow (cfs)                   | 16               | 20              | 73.2              | 146             |
| Rare flow (cfsm)                  | 0.09             | 0.11            | 0.40              | 0.80            |
| Allowable duration under (days)   | 6                | 6               | 7                 | 3               |
| Catastrophic duration (days)      | 28               | 11              | 30                | 9               |
| Bioperiod                         | Shad Spawning    |                 | GRAF Spawning     |                 |
| Approximate dates                 | May 5 - June 19  |                 | June 20 - July 4  |                 |
| Indicator                         | Min              | Max             | Min               | Max             |
| Watershed area (mi <sup>2</sup> ) | 183              | 183             | 183               | 183             |
| Common flow (cfs)                 | 143              |                 | 101               |                 |
| Common flow (cfsm)                | 0.78             |                 | 0.55              |                 |
| Allowable duration under (days)   | 13               |                 | 11                |                 |
| Catastrophic duration (days)      | 28               |                 | 15                |                 |
| Critical flow (cfs)               | 62               | 156             | 22                | 156             |
| Critical flow (cfsm)              | 0.34             | 0.85            | 0.12              | 0.85            |
| Allowable duration under (days)   | 5                |                 | 5                 |                 |
| Catastrophic duration (days)      | 13               |                 | 10                |                 |
| Rare flow (cfs)                   | 57               | 242             | 16                | 242             |
| Rare flow (cfsm)                  | 0.31             | 1.32            | 0.09              | 1.32            |
| Allowable duration under (days)   | 4                |                 | 2                 |                 |
| Catastrophic duration (days)      | 10               |                 | 3                 |                 |
|                                   |                  | GRAF Spawning   | Common shiner R&G |                 |

# R&G Season

Baseline Current Baseline Current Base. Curr.

|                                 | R&G Generic   |       | EPT community |        | C Shiner    | C Shiner c |
|---------------------------------|---------------|-------|---------------|--------|-------------|------------|
|                                 | 184           | 184   | 184           | 184    | 184         | 184        |
|                                 | Lamprey Gauge |       | Lamprey Gauge |        |             |            |
| <b>Common habitat (%CA)</b>     | <b>0.6</b>    |       | <b>0.26</b>   |        | <b>0.11</b> |            |
| Allowable duration under (days) | 27            |       | 30            |        | 46          |            |
| Catastrophic duration (days)    | 70            |       | 85            |        | 81          |            |
| Corresponding flow (cfsm)       | 0.18          | 0.37  | 0.48          | 0.81   | 0.6         | 0.95       |
| Corresponding flow (cfs)        | 33.12         | 68.08 | 88.32         | 149.04 | 110.40      | 174.80     |
| <b>Critical habitat</b>         | <b>0.42</b>   |       | <b>0.21</b>   |        | <b>0.06</b> |            |
| Allowable duration under (days) | 17            |       | 6             |        | 15          |            |
| Catastrophic duration (days)    | 30            |       | 32            |        | 32          |            |
| Corresponding flow (cfsm)       | 0.08          | 0.07  | 0.13          | 0.44   | 0.12        | 0.71       |
| Corresponding flow (cfs)        | 14.72         | 12.88 | 23.92         | 80.96  | 22.08       | 130.64     |
| <b>Rare habitat (%CA)</b>       | <b>0.34</b>   |       | <b>0.14</b>   |        | <b>0.04</b> |            |
| Allowable duration under (days) | 15            |       | 6             |        | 6           |            |
| Catastrophic duration (days)    | 28            |       | 19            |        | 28          |            |
| Corresponding flow (cfsm)       | 0.07          | 0.06  | 0.09          | 0.16   | 0.09        | 0.68       |
| Corresponding flow (cfs)        | 12.88         | 11.04 | 16.56         | 29.44  | 16.56       | 125.12     |

# Flow Dependent Protected Entities

## Recreation

- Boating
- Fishing
- Swimming

## Natural Communities

- Floodplain Forests
- Oxbow/backwater Wetlands
- Vernal Pools
- High Energy Riverbanks
- River Rapids

## RTE Plants

- Water Marigold
- Sharp-flowered Mannagrass
- Knotty Pondweed
- Small-crested Sedge
- Slender Blue Flag
- Climbing Hempweed

## RTE Wildlife

- Wood Turtle
- Spotted Turtle
- Blanding's Turtle
- Pied Billed Grebe
- Osprey
- Bald Eagle
- Sedge Wren

## Aquatic Life and Habitat

- Fish and Fish Habitat
- Mussels
- Insects
- T/E Bridled Shiner
- Banded Sunfish
- Endangered Brook Floater

## Public Water Supply

# **Public Water Supply**

## **Laws of 1965 – Chapter 322**

**“An Act Relative to Future use of Portions of the Waters of the Lamprey River and/or its Tributaries for Public Water Supplies”. Based on results of study performed for the Town of Durham and UNH for an additional water supply source.**

**Grants the Towns of Durham, Epping, Lee, Newmarket and Raymond the use of the waters of the Lamprey River and its tributaries, in these towns, for the purpose of public water supplies to the exclusion of all other municipalities.**

# Public Water Supply



## UNH/Town of Durham

- The only active user of water pumped directly from the Lamprey River within the designated segment.
- Withdrawal from Lamprey supplements water from Oyster River and pumping from Lee Well.

# Public Water Supply

## Section 401 Certificate Restrictions

- If summer flow between 45 & 21 cfs (0.25 & 0.11 cfs), 1.8 cfs (0.01 cfs) can be diverted.
- If summer flow between 21 & 13 cfs (0.11 & 0.07 cfs), 0.4 cfs (0.002 cfs) can be diverted.
- If summer flow less than 13 cfs (0.07 cfs) outflow = inflow to dam.
- Pool elevation cannot be drawn down more than 0.5 in. in 24 hours with a six inch maximum.

# **Public Water Supply**

## **UNH/Town of Durham**

- **System only pumps water from Lamprey when flow at Packers Falls gage > 45 cfs because a monitoring system is not in place above dam.**
- **Investigating the development of new water supply well near Spruce Hole Bog.**
- **May also consider artificial recharge, divert during spring runoff and recharge aquifer.**

# **Public Water Supply**

## **Newmarket Water Works**

- **Currently obtains water supply from Bennett and Sewall Wells in Newmarket Plain Aquifer.**
- **Formerly diverted water from Folletts Brook, the Piscassic River and the Lamprey River, but abandoned due to water treatment issues.**
- **Recently received Groundwater Discharge Permit for artificial recharge of Newmarket Plain aquifer.**

# **Public Water Supply**

## **Newmarket Water Works**

- **Proposed source for recharge water is a diversion from the Lamprey River. Estimated withdrawal of 500,000 gallons per day (0.77cfs or 0.004 cfs).**
- **Intake may be placed in Lee in the designated segment or in Macallen Dam impoundment downstream of designated segment.**

# **Public Water Supply**

- **No specific water supply PISF proposed.**
- **Water use by Newmarket Water Works and Durham/UNH to be evaluated during development of Water Management Plan.**
- **Conservation and Water Use Plans to be developed for each system as part of WMP.**
- **Goal is to minimize impact of water supply use on instream protected entities.**

## **Assessment of PISFs**

**As mentioned earlier UNH developed representative hydrographs for:**

- Last five years (2003 – 2007)**
- Wet three years (2005 – 2007)**
- Average three years (1990 – 1992)**
- Dry three years (1964 – 1966)**

**Proposed PISFs evaluated under these flow scenarios to estimate their impact and their range of influence.**

## Recreation PISF $Q \geq 275$ cfs

| Representative<br>Hydrograph |      |      |
|------------------------------|------|------|
|                              | Days | %    |
| Last five years              | 549  | 30.1 |
| Wet three years              | 510  | 46.5 |
| Average three years          | 407  | 37.1 |
| Dry three years              | 235  | 21.4 |

**Vernal Floodplain Pool - Spring PISF (number of days in the hydrologic record and bioperiod that the reach meets the PISF and per cent of time in the representative hydrograph).**

**March 15 - July 31     $Q < 1,500$  cfs every day**

| <b>Representative<br/>Hydrograph</b> |             |          |
|--------------------------------------|-------------|----------|
|                                      | <b>Days</b> | <b>%</b> |
| Last five years                      | 657         | 50.7     |
| Wet three years                      | 389         | 50.1     |
| Average three years                  | 405         | 52.1     |
| Dry three years                      | 417         | 53.7     |

**Wood Turtle - Summer PISF (number of days in the hydrologic record and bioperiod that the reach meets the PISF and per cent of time in the representative hydrograph).**

June 1 to October 15     $Q < 500$  cfs

| <b>Representative<br/>Hydrograph</b> |             |          |
|--------------------------------------|-------------|----------|
|                                      | <b>Days</b> | <b>%</b> |
| Last five years                      | 670         | 97.8     |
| Wet three years                      | 374         | 91.0     |
| Average three years                  | 394         | 95.9     |
| Dry three years                      | 411         | 100.0    |

| <b>Bioperiod</b><br>Approximate dates | <b>Rearing &amp; Growth</b><br>July 5 - Oct. 6 (94 days) | <b>Salmon Spawning</b><br>Oct. 7 - Dec. 8 (63 days) | <b>Overwintering</b><br>Dec 9 - Feb. 28 (82 days) |
|---------------------------------------|----------------------------------------------------------|-----------------------------------------------------|---------------------------------------------------|
|                                       | <b>Recommended flows</b><br>Common shiner                | <b>Recommended flows</b><br>Atlantic Salmon         | <b>Recommended flows</b><br>Flow                  |
| Watershed area (mi <sup>2</sup> )     | 183                                                      | 183                                                 | 183                                               |
| Location                              | <b>USGS Gage</b>                                         | <b>USGS Gage</b>                                    | <b>USGS Gage</b>                                  |
| <b>Common flow (cfs)</b>              | 110                                                      | 90                                                  | 239                                               |
| <b>Common flow (cfsm)</b>             | 0.60                                                     | 0.49                                                | 1.31                                              |
| Allowable duration under (days)       | 46                                                       | 17                                                  | 20                                                |
| Catastrophic duration (days)          | 81                                                       | 55                                                  | 57                                                |
| <b>Critical flow (cfs)</b>            | 22                                                       | 40                                                  | 110                                               |
| <b>Critical flow (cfsm)</b>           | 0.12                                                     | 0.22                                                | 0.60                                              |
| Allowable duration under (days)       | 15                                                       | 11                                                  | 10                                                |
| Catastrophic duration (days)          | 32                                                       | 33                                                  | 37                                                |
| <b>Rare flow (cfs)</b>                | 16                                                       | 20                                                  | 73.6                                              |
| <b>Rare flow (cfsm)</b>               | 0.09                                                     | 0.11                                                | 0.40                                              |
| Allowable duration under (days)       | 6                                                        | 6                                                   | 7                                                 |
| Catastrophic duration (days)          | 28                                                       | 11                                                  | 30                                                |

# PISFs vs. 3 Year Average Flow Record

| <b>Bioperiod</b><br>Approximate dates | <b>Rearing &amp; Growth</b><br>July 5 - Oct. 6 (94 days) | <b>Salmon Spawning</b><br>Oct. 7 - Dec. 8 (63 days) | <b>Overwintering</b><br>Dec 9 - Feb. 28 (82 days) |
|---------------------------------------|----------------------------------------------------------|-----------------------------------------------------|---------------------------------------------------|
|                                       | <b>Recommended flows</b><br>Common shiner                | <b>Recommended flows</b><br>Atlantic Salmon         | <b>Recommended flows</b><br>Flow                  |
| Watershed area (mi <sup>2</sup> )     | 183                                                      | 183                                                 | 183                                               |
| Location                              | <b>USGS Gage</b>                                         | <b>USGS Gage</b>                                    | <b>USGS Gage</b>                                  |
| <b>Common flow (cfs)</b>              | 204                                                      | 8                                                   | 91                                                |
| <b>Common flow (cfsm)</b>             |                                                          |                                                     |                                                   |
| Allowable duration under (days)       | 1                                                        | 0                                                   | 1                                                 |
| Catastrophic duration (days)          | 1                                                        | 0                                                   | 0                                                 |
| <b>Critical flow (cfs)</b>            | 105                                                      | 3                                                   | 13                                                |
| <b>Critical flow (cfsm)</b>           |                                                          |                                                     |                                                   |
| Allowable duration under (days)       | 2                                                        | 0                                                   | 0                                                 |
| Catastrophic duration (days)          | 1                                                        | 0                                                   | 0                                                 |
| <b>Rare flow (cfs)</b>                | 70                                                       | 0                                                   | 0                                                 |
| <b>Rare flow (cfsm)</b>               |                                                          |                                                     |                                                   |
| Allowable duration under (days)       | 2                                                        | 0                                                   | 0                                                 |
| Catastrophic duration (days)          | 1                                                        | 0                                                   | 0                                                 |

**Note:** 3 year average flow period = 1990 to 1992.  
 Numbers listed as flows are the number of times in the record PISF not met.  
 Numbers listed as durations are number of years PISF not met.

# PISFs vs. 3 Year Low Flow Record

| Bioperiod<br>Approximate dates    | Rearing & Growth<br>July 5 - Oct. 6 (94 days) | Salmon Spawning<br>Oct. 7 - Dec. 8 (63 days) |  | Overwintering<br>Dec 9 - Feb. 28 (82 days) |  |
|-----------------------------------|-----------------------------------------------|----------------------------------------------|--|--------------------------------------------|--|
|                                   | Recommended flows<br>Common shiner            | Recommended flows<br>Atlantic Salmon         |  | Recommended flows<br>Flow                  |  |
| Watershed area (mi <sup>2</sup> ) | 183                                           | 183                                          |  | 183                                        |  |
| Location                          | USGS Gage                                     | USGS Gage                                    |  | USGS Gage                                  |  |
| Common flow (cfs)                 | 261                                           | 128                                          |  | 180                                        |  |
| Common flow (cfsm)                |                                               |                                              |  |                                            |  |
| Allowable duration under (days)   | 3                                             | 3                                            |  | 3                                          |  |
| Catastrophic duration (days)      | 1                                             | 2                                            |  | 1                                          |  |
| Critical flow (cfs)               | 203                                           | 61                                           |  | 111                                        |  |
| Critical flow (cfsm)              |                                               |                                              |  |                                            |  |
| Allowable duration under (days)   | 3                                             | 3                                            |  | 2                                          |  |
| Catastrophic duration (days)      | 3                                             | 0                                            |  | 1                                          |  |
| Rare flow (cfs)                   | 167                                           | 15                                           |  | 58                                         |  |
| Rare flow (cfsm)                  |                                               |                                              |  |                                            |  |
| Allowable duration under (days)   | 3                                             | 1                                            |  | 2                                          |  |
| Catastrophic duration (days)      | 2                                             | 1                                            |  | 0                                          |  |

**Note:** 3 year low flow period = 1964 to 1966.  
 Numbers listed as flows are the number of times in the record PISF not met.  
 Numbers listed as durations are number of years PISF not met.

# Wiswall Dam and Durham/UNH Water Supply

45 cfs > Q > 21 cfs can withdraw 1.8 cfs

21 cfs > Q > 13 cfs can withdraw 0.4 cfs

Q < 13 cfs no withdrawal (only from storage)

| Representative Hydrograph | 45-21 cfs |      | 21-13 cfs |     | <13 cfs |      |
|---------------------------|-----------|------|-----------|-----|---------|------|
|                           | Days      | %    | Days      | %   | Days    | %    |
| Last five years           | 150       | 8.2  | 99        | 5.4 | 158     | 8.7  |
| Wet three years           | 86        | 7.8  | 64        | 5.8 | 37      | 3.4  |
| Average three years       | 73        | 6.7  | 52        | 4.7 | 53      | 4.8  |
| Dry three years           | 149       | 13.6 | 82        | 7.5 | 146     | 13.3 |

# Final Recommendations

1. PISF for fish controlling flows.
2. Flow no less than 4 cfs.
3. Additional conditions for RTE, plant communities and wildlife habitat.
4. PISFs maintained by implementation of Water Management Plan.



# Final Recommendations

## Additional Conditions:

### Winter Survival and Development - December 1 through April 30

- >130 cfs monthly mean – wood turtle
- >500 cfs for 1 week or more – herbaceous low riverbank, mannagrass, hempweed
- <1,500 cfs daily mean in April – vernal floodplain pool, Blanding's turtle

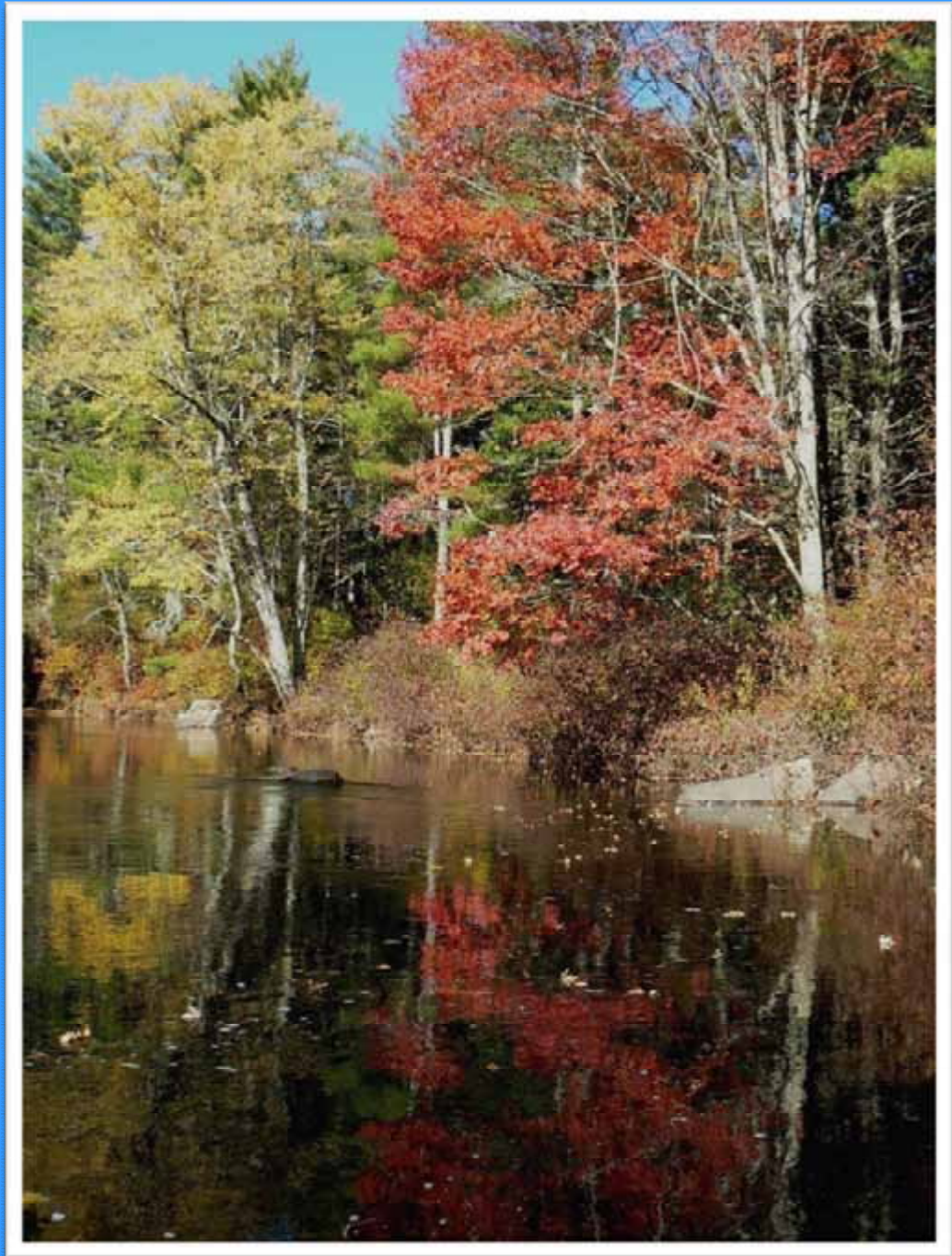
### Spring Spawning May 1 through June 30

- >100 cfs monthly mean – riverweed, knotty pondweed
- <500 cfs daily mean in June (wood turtle)
- <1,500 cfs daily mean in May - Blanding's turtle, floodplain vernal pools

### Summer Survival and Development – July 1 through Sept 30

- <500 cfs daily mean in July – wood turtle
- $\leq 60$  cfs daily mean in August/Sept – Herbaceous low riverbank
- <100 cfs monthly mean – August /Sept – riverweed, knotty pondweed

**Comments or  
Questions?**



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